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GOVERNMENT SUPPORT FOR RESEARCH IN GREAT BRITAIN

THE report of the Advisory Council for Scientific and Industrial Research for the year 1954–55 (see p. 768 of this issue) discusses at some length the position of the research associations in the national organization for research; but this is only one of a number of major matters of policy that are dealt with in the report. During the year, the first financial year of the Department's five-year plan was completed, and the Advisory Council records that the provision of resources within the framework and terms of the plan has proceeded smoothly. The provision in the Ministry of Works Votes for services to the Department in 1955–56 is £2,039,200 against £1,497,500 in the previous year, the increase being due mainly to increased provision for major building works, notably for the National Physical Laboratory, the Mechanical Engineering Research Laboratory, the Radio Research Laboratory and the Building Research Station.

The one exception to the smooth implementation of the five-year plan is in regard to staff, the increase of 159 being again less than the 200 provided for in the plan. Continuous and expanded efforts were made to recruit suitable scientists, and the Advisory Council believes that the authority and financial resources are adequate for the objective. While it is admitted that on occasion difficulties in competing in remuneration may be a partial explanation, the shortage is attributed mainly to the increasing general demand for scientific and technical staff and to the shortage of scientists and technologists which the Government's plans for the expansion of technological and technical education are intended to relieve.

While those plans are coming to fruition, it is inevitable that the use which is made by the Department of its scientific and technical man-power will be the more closely scrutinized, and the estimate of the distribution of effort given in the present report will be of particular interest. Information supplied to the Advisory Council indicates that over the Department as a whole 25 per cent of effort is being applied to "Advisory work and *ad hoc* investigations", 45 per cent to "Applied Research" and 30 per cent to "Background (or basic research)". A quarter of the Department's effort is thus being spent in helping to ensure that the results of its work are widely known and applied in industry.

The Advisory Council stresses the importance of making every effort to get the results of the work of the Department's establishments widely known in quarters in which they can, and will, be applied to industrial practice, and it would be undesirable to take any steps which would discourage free approach to the establishments by potential users for scientific help to solve their practical problems. Nevertheless, it must be a matter for judgment as to what proportion of the Department's effort should be spent on such advisory and related work, and one which depends to some extent on the position and efficiency of the information services of the country and the existence within the individual industrial firms of those qualified to appreciate the significance of scientific and technological advance and its application to their own processes and problems. To this extent the problem is linked up with that of scientific and technological education.

While the Advisory Council's estimate that 25 per cent of the Department's effort should now be spent on this purpose may well be reasonable, the situation will obviously have to be watched. This the Council proposes to do, in order to prevent undue emphasis on advisory work, to the detriment of new scientific 'capital' for future application. It notes indeed that the establishment and development of information services by trade associations and research associations could be of service here; but it might well have urged the value of developing as a first priority the proposed Science Centre in London, as well as a national library of science and technology and a new science lending library. The regional developments which stem from such national facilities should at least relieve the Intelligence and Information Division of the Department of some of its present work.

The size of the latter Division and the scope of its activities obviously require consideration, not only in relation to the total effort of the Department itself but also in relation to the information services available in Britain as a whole. Since the Advisory Council discussed the functions of the Division in its report for 1952–53, expenditure on the Division has risen from £58,119 in 1952–53 to £71,365 in 1955–56 and to £79,674 in 1956–57; but the staff has changed but little, being given as 80 in 1955–56 and 83 for 1956–57, compared with 76 in 1952–53. The increase is in fact in the range of the smallest, proportional to present numbers, for which the Advisory Council provided in the gradual allocation of the six hundred additional posts for non-industrial staff available for the four years beginning April 1, 1955, coming with the five per cent for building research, seven per cent for forest products research and nine per cent for the National Physical Laboratory. At the other end of the scale are the 112 allocated for mechanical engineering research (an increase of 45 per cent), the increase for hydraulics research being 50 per cent and for radio research 31 per cent.

These distributions were based on the Advisory Council's considered views of how best to distribute resources made available to the Department, and on its assessment of the relative strengths of the needs of the individual stations; it should be noted that even the 9 per cent increase at the National Physical Laboratory represented the second largest allocation of staff—seventy—for the period. Availability of accommodation and the relative ease or difficulty with which special types of staff could be recruited

also influenced the allocations; but it is quite clear from this report that the Advisory Council is well aware that the total man-power demands of the Department have to be considered in relation to those of the country as a whole and that it takes a balanced view of its responsibilities.

The five-year plan has in fact provided a reasonably stable basis on which the various research boards and directors of research can plan their activities for the next few years; but it is not suggested that it has made it possible for the Department to meet all the requests that it receives. The Industrial Grants Committee, the Scientific Grants Committee and the Nuclear Physics Committee have all pleaded for more money and for priority of claim on departmental reserves, and the Advisory Council also refers to the way in which universities look to the Department to provide the means for initiating new and promising lines of research for which the normal resources of a university are inadequate. Here, however, there arises a further consideration. The resources allocated by the Department in this way call for consideration in relation to Britain's total expenditure on fundamental research. It is not solely within the Department that it is desirable to keep current programmes in accord with available resources, and to review and adjust them constantly to meet changes in the relative importance of different objectives. No accurate information is available as to the proportion of the £34 millions of the vote for universities and colleges in the 1956–57 estimates which is spent upon research; but the grant for research and development generally in the 1956–57 estimates is increased by some £25 million on last year.

This increase includes industrial as well as academic research; but the two are not always sharply separated, particularly in the nuclear field, in respect of which misgivings have already been expressed as to the balance of research effort in Britain. The Advisory Council in this report points to the need for unhesitating reduction or elimination of effort on projects less likely to yield valuable results, in order to release resources for new projects, and emphasizes that it is not sufficient to be satisfied that a project is of value. Selection is equally essential if the national research effort is to be in balance, and if the resources of the Department of Scientific and Industrial Research are to be concentrated on the more urgent objectives and those with best prospects of success; that, it is suggested, is the continuing responsibility of research boards and directors of research. The report does not discuss further this prime difficulty of selection, nor does it suggest that the problem of discontinuing research is being burked in the Department. There is, however, a comment that the boards and directors should be prepared to consider the abandonment of effort in a particular field when that which an establishment is able to make is small compared with what is being done elsewhere.

In this comment there is a clue to the Advisory Council's view of the broad function of the Department's research activities. That effort, it is implied, should in the main be concentrated on lines desirable in the national interest but which otherwise are unlikely to be pursued. It would follow that once research in these fields is firmly established and is being promoted by other bodies, either in industry, independent institutions or universities, government support should be gradually withdrawn. This would in effect make the function of the Department broadly similar to that of the independent foundation such as the Nuffield Foundation or the Carnegie Trust, with the difference, of course, that the Department cannot expect to enjoy quite the same freedom to experiment as the independent institution. Its activities must be more closely aligned to proposals clearly seen to be related to the immediate interests of the nation. It will step in where the independent institution has uncovered a promising lead, and withdraw when it seems a probable and reasonable expectation that other sources will provide the continuing support required.

That does not, however, dispose of the difficulty of the selection of research projects in the first instance or of deciding on the appropriate moment to withdraw or terminate support. It may, in fact, be more difficult for an executive than for an advisory body to make the latter decision, for in the last resort it is the scientist engaged in the project who alone can best judge how near the project may be to success, and even that judgment may easily err. What an advisory body can do is to bring to the notice of those engaged in the project external factors or conditions which may make its success of less concern from a national point of view or warrant handing over the project to some other organization by which it can be continued with greater resources or higher prospects of success. It should not be imagined that any external committee is better able to judge of the prospects of success than those scientists or technologists engaged in the project: all that can be done from outside is to advise, or decide, as to the appropriateness of continuing the project in the national circumstances of the moment.

Judgments as to the prospects of success and as to projects which are most worth while from the point of view of science or technology are best made —and only soundly made—by scientists and technologists themselves, and from that point of view too much stress cannot well be laid on the value of the Department's postgraduate maintenance grants to assist the universities in meeting the national need for trained research workers. These grants may well assume even greater importance as the expansion of technological education proceeds, and here is a further reason for urging that the supervision of technological education should be entrusted to some one body corresponding in functions and status to the University Grants Committee, if indeed the responsibility is too great to be discharged effectively by the latter body.

There is, however, another point at which the work of the Department of Scientific and Industrial Research impinges on technological education, and that is in the work of the research associations. That scheme is now some thirty-eight years old, and ten

years ago it was announced that the Government would continue indefinitely its financial contributions through the Department, in the belief that co-operative research is an important means of increasing industrial efficiency but that industry is best fitted to decide what are its own scientific problems and the best means of solving them. The present report from the Advisory Council records at some length the progress and development in the research association movement over the past five years in the light of a report received from its Industrial Grants Committee.

In the first place, the Advisory Council stresses the autonomy of the research associations. Conditions attached to the Department's grants do not materially affect the powers of direction and control possessed by the council of any association, which is elected by the ordinary membership. The terms of government grants to a research association are designed to meet its particular circumstances, including its stage of development; and they are based on information which enables the Industrial Grants Committee to judge both the suitability of an industry for co-operative effort and the extent to which encouragement is justifiable in the national interest. The grant to be recommended is then assessed, after considering the programme of research, its significance to the industry, its cost and the scientific status of the association in question.

It may, of course, be objected that this is done from outside the industry, and that it is at variance with the belief expressed above that an industry is best fitted to decide what are its own scientific problems and the best means of solving them. No research association, it is true, can hope to select problems for investigation with the same certainty as to their industrial importance as the individual firm; but it can judge those likely to possess national importance as well, and it may promote the attack on problems which are better handled in collaboration and do not involve an element of competition. Moreover, the developments of the past five years indicate also the value of the research association as a means of distributing benefits to an industry and encouraging the attack on more general problems such as operational research, methods of quality control, the study of consumer needs and human factors in industry. During this period, the research associations have received under the Technical Assistance Programme of the United Nations Economic Co-operation Administration, later the Mutual Security Agency, and now the International Co-operation Administration, allocations amounting to about 800,000 dollars for equipment, 30,000 dollars for the provision of current and back numbers of books and periodicals to fill gaps in their information and library services, and 7,600 dollars for visits to the United States by scientific and technical teams to obtain information. They are at present receiving further assistance from the United States under 'Conditional Aid' for the promotion of productivity.

The work on human relations in industry and on individual efficiency in industry, much of which is financed by grants received under the Conditional Aid Scheme for the use of Counterpart Funds derived from United States Economic Aid, adds a fourth category to the three main fields of activity of the research associations, and the Advisory Council recognizes the need to pursue this type of work. The Conditional Aid Programme is due to end on, or shortly after, June 1956, and the Advisory Council suggests that increased resources should be made available for such research, and that it should not be undertaken merely at the expense of the older types of work. Careful consideration is being given to the possible basis of a long-term programme of work in this field financed from departmental funds.

Such work in itself is related to technical education, in that some of it is specifically concerned with the removal of misunderstandings and other difficulties which attend the introduction of new processes and new products or materials in industry. Besides this, the part which the research associations might play in support of technological and technical education was touched upon at a conference in June 1951 and was the sole subject of a conference held in November 1953, as a result of which the ties between individual research associations and technical colleges have been strengthened. The contribution which the research associations might make to technical and technological education is being increasingly recognized, though it was overlooked in the recent White Paper on Technical Education. Probably it is in promoting the recruitment of scientific and technical staff by an industry, as well as in making an industry more research-minded and receptive of new ideas, that the research associations exercise their major educational influence. Nevertheless, Dr. P. F. R. Venables did well to emphasize, in his recent book, the value of a greater interchange of staff between the technical colleges and research associations, as well as industry generally.

This question of technical education is the continuing problem presented alike by the small firm and the small yet well-defined industry unable to finance a fully constituted research association with the minimum overheads essential for really competent scientific guidance and work. For such industries the Advisory Council has sought to foster association of the smaller ones with existing and industrially related research associations. Examples of this relation which promise to meet with success are the arrangements made between the Cutlery Research Council and the British Iron and Steel Research Association, and between the latter and the File Research Council.

There are other problems presented by the small firm; but it should be remembered that, as the survey carried out for the Manchester Joint Research Council has indicated, a major difficulty is the absence in so many small firms of those competent to assess the significance of scientific and technical advance for the activities of the firm. This, however, is a matter of technical and scientific education. For the present, it appears to the Advisory Council that the past five years have demonstrated the strength and vitality of the research association

movement as a whole, and the firm belief of most of British industry in the value of their associations. It concludes that industry as a whole has been spurred to increase its support of research associations by the economic situation during recent years and by some falling-off in the rate of increase of government support. Many associations, however, have far to go before their resources and activities are as large as their industries require and can reasonably be expected to support; nor are there any which, in the Advisory Council's opinion, could not usefully be expanded. Moreover, it believes that some of the terms of grant fixed in 1951 may prove to have placed too heavy a load of responsibility on the industry.

Although in terms of purchasing power there has been a substantial increase in the total income of the research associations and in industrial support, the Advisory Council is clear that inflation slows down the development of activities and sometimes causes serious financial embarrassment. It is in consequence in considerable doubt as to the adequacy of the funds at present expected to be available under the five-year plan for what was contemplated. This, it is clear, applies equally to the research establishments of the Department, and it is these and related problems that should be the prime concern of the Government at the moment. There is little evidence of misdirected effort but much of the need for clear thinking and careful assessment of the place of the Department in the nation's research organization, and it is to such problems that the Bill now before Parliament should primarily direct attention.

ORIGIN OF THE VERTEBRATES

The Origin of Vertebrates

By Prof. N. J. Berrill. Pp. viii+257. (Oxford: Clarendon Press; London: Oxford University Press, 1955.) 25*s*. net.

FOR a long time zoologists have accepted for embryological reasons the general proposition that vertebrates are more closely related to echinoderms than to arthropods or annelids, which they resemble superficially in segmentation. This belief has usually been combined with acceptance of the theory that vertebrate descent has involved neoteny, eliminating a sessile adult feeding phase. Willey and Garstang combined these two views in the supposition that the chordate, swimming by muscles, evolved from a ciliated echinoderm type of larva. Prof. Berrill is prepared to accept both the first two theses, but not to put them together as Willey and Garstang did. He believes that the ancestor of the chordates is to be found in the ascidian tadpole and that this was evolved not from a ciliated larva but as a special adaptive phase, concerned with the selection of a suitable location for the sessile adult.

To prove this thesis he draws on his great knowledge of tunicates, their ecology and their embryology. He points out that the tadpole's life is very short, sometimes as little as one hour. The animal consists almost wholly of a locomotor tail and receptor organs with which to guide it. Moreover, the tadpole is best developed in those species in which the adult requires a clean rock surface or some other relatively specialized surface upon which to develop. Such sites are usually at a premium—vertical or overhung surfaces, often swept bare by currents. They therefore have to be sought out by the larva. In groups such as the Molgulidae, where the adults live 'free' on a sandy bottom, the tadpole stage is absent.

His thesis that the tadpole is a new tunicate development is supported by a beautifully concise account of this exceptionally simple creature with its notochord of forty cells, with eighteen muscle cells on each side. He draws also upon investigations by Conklin and Dalcq into the localization of organ-forming substances in the egg and makes a bold suggestion as to how the whole tail structure could result from a simple mutation. If one part of the egg became changed so that a few of the cells of the gastrula swelled by formation of vacuoles to make a notochord, then, he suggests, the cells on either side would acquire myofibrils because of stretching and the nervous system would be pulled out into a tube. The chordal tissue would thus influence adjacent tissues, setting the pace of growth as he puts it, though he does not pursue the thought to the evocative powers of the vertebrate chordamesoderm. His point is that a crude form of tadpole could be produced by relatively simple changes of morphogenesis, though, as he observes, it would need receptor organs to guide its swimming.

Whether we follow Prof. Berrill in his hypothesis or not, it reminds us of the fascinating possibilities that these larvæ present for study. For example, the myofibrils run continuously through the cells all along the tail. All the control is from the front end and the 'neural tube' contains no nervous tissue. It has to be explained, however, how it comes to do so in the neotenous Appendicularia, in which development is otherwise very like that of other tunicates. Ingenious though the thesis is, it does not demonstrate conclusively that the simple ascidian tadpole represents the earliest type of chordate. It is difficult to exclude the possibility that its simplicity is due to the specialization for habitat-seeking to which he directs attention. Above all, it does not provide us with an answer to the question: What were the larvæ of our ancestors like before they were tadpoles? The enteropneust tornaria is so like an echinoderm larva that it is difficult to believe it can be dismissed as "an innovation far from primitive" as Berrill suggests. Similarly he dismisses hollow nerve cords and enterocœles as unimportant indicators of affinity, because they are due to a "simple process of folding". He several times introduces this concept that foldings of epithelial layers are the simplest form of morphogenetic process—an interesting topological and embryological question. We cannot, however, afford to discard clues in the similarities of developmental processes, at least until the underlying morphogenetic forces are understood. It is scarcely sufficient to say of an organ, as Berrill does of the nerve cord of *Balanoglossus*, that it is "inevitably situated where it is found".

He is equally provocative about the later stages of vertebrate evolution, interpreting the development of *Amphioxus* as derived from that of ascidians by a slowing of the rate of differentiation of all the tissues by a "weakening of the ascidian crescental agents", which might have come about by a relatively simple mutation.

These are only some of the ways in which the author has succeeded in showing the stimulating value of studies of the morphology and embryology even of

such creatures as sea squirts. He provides some very interesting comments also on the adult structure of tunicates. There is a good account of the subneural apparatus and of the work of Huus and Carlisle on its possible receptor functions, with all that this implies for the origin of the vertebrate pituitary gland. Berrill adds the interesting suggestion that the dorsal cord, a strand of cells between the subneural gland and the gonad, controls release of the genital products by "neuroid or hormonal transmissions along its plasmal surface". Almost as an aside he introduces the conception of the tunicate epicardium as the ancestor of the coelom. All these and many other questions are discussed lightly, concisely and yet with full scholarly appreciation of their significance, making a book that every zoologist can enjoy.

J. Z. YOUNG

WILD-LIFE REFUGES IN THE UNITED STATES

Seeing America's Wildlife in our National Refuges
By Devereux Butcher. (Prepared under the Auspices of Defenders of Furbearers.) Pp. ix+338. (New York: The Devin-Adair Company, 1955.) 5 dollars.

WILD-LIFE refuges in the United States are so many, so far-flung and so astonishingly rich in vertebrates that to become familiar with the majority is an unattainable ambition for all but a very few, even of Americans. Most European naturalists have only the vaguest idea of them. One should therefore be grateful to Mr. Devereux Butcher for this highly informative book, with its three hundred and fifty excellent half-tone illustrations, which show a generous sample of the mammals and birds of the refuges, and a fair but smaller sample of the refuges themselves. Forty-one of them are briefly described, together with a number of national parks and other public and private refuges. Nevertheless, the author is compelled to dismiss more than a hundred other refuges of the Federal Fish and Wildlife Service alone, in a final ten-page summary, although several of these are each larger than all the nature reserves in Britain put together. Many hundreds of interesting State refuges cannot even be mentioned by name.

Mr. Butcher has made his selection wisely from a wide variety of habitats and regions, although coastal, desert and mountain refuges naturally come off best, and the representation of New England and the Middle West and Prairie states is disappointingly thin. He has packed his descriptions with accurate and up-to-date facts, with a minimum of padding but with a vivid and colourful presentation of what each has to show and of the achievement which it represents. The propaganda for the defence and expansion of the system and against rival interests, particularly shooting men, rings somewhat stridently to a British ear; but apart from differences in national character and tastes, it must be borne in mind that the problems created by some fifteen million 'hunters', or shooting men, have no sort of parallel in Great Britain, while threats to alienate national parks and refuges for economic or defence purposes have recently grown to very serious proportions in the United States just as much as in Britain. Nevertheless, the reader should not forget that the American restrictions on shooting wild-life, which receive bare mention in this book, are far more drastic and more strictly enforced than anything ever contemplated in Britain, and that not all who are in a position to judge would agree with, for example, the author's condemnation of the Department of Interior for permitting the New York State Throughway to be driven across the marshes of Montezuma Refuge, in view of the improved control of water-levels which it facilitated.

American wild-life is often astonishingly tolerant of human beings, who will no doubt be tempted by this most attractive book and by growing prosperity and leisure to flock to the refuges in alarming numbers. The author appreciates the danger, at any rate for the California condor, which can be prevented from feeding its only chick all day by one man showing himself within five hundred yards of the nest for a few minutes only.

Characteristically, but in contrast to British practice, the vegetation and invertebrate fauna are treated as little more than background for the main drama of the vertebrate actors. There is a certain amount of history but relatively little ecology, and little attention to the natural as against the human dangers to the successful management of refuges. It seems too much to hope that this fairly expensive work can be widely bought by private individuals in non-dollar countries; but it should not be missing from any serious library concerned with Nature and its conservation.

E. M. NICHOLSON

CATALYTIC HYDROGENATION

Catalysis
Vol. 3: Hydrogenation and Dehydrogenation. Edited by Paul H. Emmett. Pp. vii+504. (New York: Reinhold Publishing Corporation; London: Chapman and Hall, Ltd., 1955.) 100*s*. net.

WITH the appearance of the third volume this comprehensive work on catalysis begins to take a new form, in that a specific type of catalytic reaction is considered in place of catalysis in general. The present collection of monographs deals with various aspects of catalytic hydrogenation. Much can be learned with regard to the mechanism of the catalytic activation of hydrogen itself from reactions such as the ortho-parahydrogen conversion and hydrogen–deuterium exchange, which are treated in an initial chapter by B. M. W. Trapnell. Catalytic hydrogenation, however, involves also the simultaneous activation of a second component, namely, the substrate to be hydrogenated; and the mechanism of this two-component process, in the typical case of the hydrogenation of ethylene, is discussed fundamentally and very clearly in the subsequent monograph by D. D. Eley. The next three sections, on the catalytic hydrogenation of olefinic hydrocarbons in general, by B. B. Corson, on the addition of hydrogen to acetylenic linkages, by G. C. Bond, and on the hydrogenation of nitro compounds, by H. A. Smith and W. C. Benoit, have largely a practical character and deal with aspects such as selective hydrogenation and the degree of specificity which can be exerted by variations in the hydrogenating metal and in the working conditions.

In connexion with a review of the present state of industrial reactions involving hydrogenation, a wel-

come emphasis is laid on the synthesis of ammonia. The general progress of the synthesis, including a discussion of the inherent requisites for good ammonia catalysts, is dealt with by W. G. Frankenburg on the basis of the necessary activation of the nitrogen, by chemisorptive linking of suitable bond-strength to the catalyst, in addition to the activation of the hydrogen. This is followed by a monograph by a group of chemists from the Dutch Staatsmijnen on research on the ammonia synthesis since 1940, the outstanding feature in this section being a clear exposition of the mechanism of promotion. The synthesis of methanol is discussed by G. Natta with special reference, first, to the necessary specificity of action which is required in the catalysts employed in order to avoid the formation of polymeric products, and, secondly, to the merits of particular catalysts. R. Feuge contributes a practical account of modern methods of working in the industrial hydrogenation of glyceride oils. In this, the discussion of forms of nickel catalysts alternative to kieselguhr-supported nickel prepared by the reduction of basic nickel carbonate is particularly valuable. Finally, the technical dehydrogenation of hydrocarbons in the petroleum industry is described, perhaps too briefly, by K. K. Kearby.

Considered as a whole, this volume represents a fair balance between the academic and the industrial aspects of hydrogenation. Its component articles are of a consistently high quality. It certainly stands out from the earlier volumes of the work, in particular from the point of view that chapters containing tables of largely undiscussed references to patent and other literature are absent; and Dr. Emmett is to be congratulated on assembling, within the compass of some five hundred pages, such an authoritative and internationally contributed description of catalytic hydrogenation.

E. B. Maxted

AUTOMATIC REGULATION

Servomechanism Analysis

(McGraw-Hill Electrical and Electronic Engineering Series.) By George J. Thaler and Robert G. Brown. Pp. xii+414. (New York and London: McGraw-Hill Book Company, Inc., 1953.) 60*s*. net.

At a time when so much is written and talked about the automation of manufacturing processes, the automatic control of aircraft, guided missiles and the like, a book is welcome which sets out to give the mathematical background for the analysis and design of servomechanisms. The present volume under review is written in a fluent and clear style and contains a great number of worked examples and of problems enabling the student to ascertain whether he has grasped the contents of the chapters he has read and to gain some experience in handling actual problems of control. A very welcome feature is a brief and sufficiently clear introduction to the theory of Laplace transformations which are used throughout the book.

As problems of electric circuits can usually be solved with not too great difficulty either directly or with the aid of analogue computers, electrical analogues are set up of mechanical, thermal, hydraulic and pneumatic systems. The book then deals with the transient analysis of servomechanisms, that is, the derivation, solution and discussion of their differential equations for determining the main criteria of performance, the speed of response, the steady-state error, the maximum overshoot and the resonant frequency for the case when changes in input or output occur. Proportional as well as derivative and integral control are dealt with.

The next chapter deals with transfer functions and their graphical representation, the transfer function being defined as the complex ratio of the output of the device to its input (p. 112). The authors seem to be not quite consistent in that a few pages later (p. 126) they call this ratio the frequency response function, while the direct transfer function is defined as the ratio between output and error, this latter being the difference between input and output. The reason for this apparent inconsistency is given on p. 140 and following.

Simplifications are made for the mathematical analysis by replacing complicated schematic drawings by equivalent block diagrams and by introducing a shorthand notation for the transfer function, representing it as the product of a constant factor K and a complex factor G. The symbols K and G are replaced by A and F respectively if a control element is used in the feedback path. Frequency response curves and curves of direct and inverse transfer functions are given in rectangular and polar co-ordinates, respectively. Then the performance of servomechanisms is analysed from equations and plots, stability criteria are discussed at some length, a classification of the systems is given and figures of merit are defined. Only very brief chapters deal with the introduction to design and with gain adjustment. A trial-and-error method and direct methods for the gain adjustment are given.

Where gain setting alone is not sufficient for obtaining the desired values of resonant frequency and steady-state error, some kind of compensation must be applied either in the main circuit or in a parallel circuit. Series and parallel compensation are therefore dealt with at some length in the next two chapters. Then it is shown how, by the use of logarithmic co-ordinates, analysis and design may be simplified in many cases. A brief chapter deals with relay servomechanisms as these find wider and wider application. Here electromechanical relays are used for applying full power to the output when the error is excessive and to maintain it until the error is sufficiently reduced. The final chapter, dealing with the 'root-locus method', might be of particular interest, as this method claims to combine to some extent the advantages of the transient and the transfer function analysis. But, due to limitations of space, only the elements are given and the chapter is somewhat sketchy.

The authors do not claim originality for the material contained in this book, but have found in their teaching practice that the arrangement and detail of presentation are well suited for the student. This is also my impression. While the various systems of servomechanisms are treated in the text in a rather abstract manner, the student will find in the appendixes, apart from some useful tables, more detailed physical and technological descriptions of the components used, like error detectors, controllers, servomotors and compensating devices. A subject-matter index and a bibliography of 206 items complete this well-produced book. As is not uncommon in American publications, only very few references are made to British and Continental sources.

R. Neumann

Index of Mathematical Tables from All Branches of Sciences

Prepared by Dr. Karl Schütte. (Index Mathematischer Tafelwerke und Tabellen aus allen Gebieten der Naturwissenschaften.) Pp. 143. (München: R. Oldenbourg, 1955.) 14.50 D. marks.

BEFORE reviewing the contents of this book, it is of some interest to recall a few facts concerned with the relatively short history of such works. It was in 1873 that British mathematicians first conceived the idea of publishing a survey of available tables, and their efforts were responsible for the appearance in 1875 of the "Encyclopaedia of Mathematics" which listed some 750 tables in all. In the meantime, with the growth of technological research, involving as it does much detailed computation, the number of tables has steadily increased, and the comparatively recent "Index of Mathematical Tables", by Fletcher, Miller and Rosenhead, of 1944, gives a selection of more than two thousand.

The author of the book under review explains that his own work was begun before the Second World War and was temporarily halted for the duration thereof; on examining Fletcher's "Index" in 1946, he found that nearly four-fifths of his entries were not in fact shown in that work; he thus decided to complete it, there being in any event no German counterpart of recent date. He claims some twelve hundred entries, of use to "calculators" of various kinds, belonging to all the branches of applied science. He also claims, justifiably I feel, that its comprehensiveness and clear order enhance its value considerably, pointing out at the same time that out-of-date tables and all three-figure ones have been omitted.

The book is divided into sixteen chapters, with sub-sections where appropriate. The first four deal with general calculating (including harmonic analysis), logarithms, natural circular functions, and logarithms of these. Of the remaining twelve, those worthy of special mention deal with the theory of numbers (including primes), gamma functions, elliptic functions, Bessel functions and the many other varieties with which mathematicians and physicists are familiar. It would be unfair to omit mention of those referring to chemistry, astronomy, meteorology, geophysics and navigation. A very full (and almost formidable) list of authors whose publications are listed is provided, together with a similar list of institutes.

J. H. PEARCE

General Physics

By Prof. Oswald Blackwood and Prof. William Kelly. Second edition. Pp. x+704. (New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1955.) 54*s*. net.

Introductory Applied Physics

By Norman C. Harris and Edwin M. Hemmerling. Pp. viii+729. (London: McGraw-Hill Publishing Company, Ltd., 1955.) 50*s*. 6*d*.

EACH of these beautifully produced books from the United States is written for a specific purpose which is somewhat different from that of the ordinary text-book. Profs. O. Blackwood and W. Kelly give an introductory course based on no more initial background than awareness of the obvious impacts of physics upon everyday life. Indeed, their hints on the solution of simple equations, arithmetical extraction of square roots, and the pronunciation of unfamiliar words, show that they assume a fairly low threshold for some students. They are also quite determined that this shall be no excuse for being content with a superficial knowledge of the principles of physics. A thorough understanding of the simpler processes of physics, and a sensible appreciation of its applications, are brought within the grasp of any careful reader, and this is no mean achievement. As in most books of this kind from American universities, the treatment of elementary mechanics is particularly good. The price puts it beyond the reach of British schoolboys (and, *a fortiori*, of their teachers), and it is in any event difficult to see where it would fit into any ordinary scheme of instruction in Britain; but it can be recommended to the librarian with a surplus to expend.

N. C. Harris and E. M. Hemmerling, writing for students in junior technical colleges, also assume only an elementary knowledge of mathematics; but having a much fuller background of scientific knowledge to exploit, they work at a more exacting level. Here the emphasis is on industrial applications. Heat engines, refrigeration and air-conditioning are pursued in great detail, and there is a very thorough treatment of alternating current and electronics. The standard is not advanced in the academic sense, and the whole is within the capacity of the young technical student, who should find it an inspiring book. This also is priced at library level.

G. R. NOAKES

Chemistry for Our Times

By Elbert C. Weaver and Laurence S. Foster. Second edition. Pp. vi+666+8 plates. (London: McGraw-Hill Publishing Company, Ltd., 1954.) 30*s*.

ALTHOUGH written as a text for American high schools and university freshmen, the theme of the book is chemistry as it affects the citizen. In the preface to the first edition (1947) the authors maintained that the atomic age called for a new approach to the study of chemistry. In framing this, fundamental principles and industrial applications were treated in due proportion and always with the humanistic appeal. Thus, while the factual chemistry was not much more than that required for British O-level examinations, it was accompanied by many literary quotations, and an abundance of information on such topics as the cyclotron, cosmetics, dyes, nuclear energy, and accounts of economic applications of chemistry. Numerous striking and even sensational stories, and many good illustrations in half-tone, heightened the effect. The idea seemed to be to attract students to the study of chemistry by extolling its spectacular advances. The theoretical explanations, clear but nowhere deep, were clever in their simplicity.

In this, the second edition, the authors have deleted the more sensational stories and pictures, have shortened the literary quotations, recast the appendixes, removed the coloured frontispiece but inserted eight coloured plates, and added items to make their work more of the style of the conventional text-book. These changes in their aggregate reduce the number of pages from 737 to 666. Yet this remains a remarkable book. Many plates have been replaced by others depicting more recent procedures. Although expensive, and scarcely suited as a class-book for any British examination, it should appeal to the student of humanities desirous of having chemical achievement introduced and interpreted to him: it would also make a welcome addition to a school library.

G. FOWLES

DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH

ANNUAL REPORT FOR 1954–55

THE annual report of the Department of Scientific and Industrial Research for the year 1954–55* includes the report of the Committee of the Privy Council for the year ended September 30, 1955, over Lord Salisbury's signature, and the fortieth report of the Advisory Council, signed by Sir Hugh Beaver, which gives the usual summary of work carried out by the various research stations and boards and research associations. Besides the summary of the Department's expenditure for the year ended March 31, 1955, there are appended lists of assessors to the Advisory Council, of the various committees of the Advisory Council, of research boards of the Department and their membership, of grants for special researches in progress or authorized during the year, of students awarded maintenance allowances for postgraduate training in research and a 49-page list of publications issued during the year. The Advisory Council can fairly claim at the outset that the Summary of Work and Appendixes afford a valuable means of obtaining easily detailed information regarding the work of the Department in widely varying fields; but the question as to whether the present organization is adequate to deal efficiently with matters of public relations remains to be determined. The persistence and the character of Parliamentary questions suggest that the problem is not yet solved, and it is improbable that an annual report of this type can contribute greatly to a solution.

The gross expenditure of £6,685,400 compares with £5,865,279 in the previous year and is reduced to £5,898,016 net by various receipts (£370,536 being from the National Physical Laboratory) for work done for government departments or for industry, the net increase on 1953–54 being £643,674; the estimates for 1955–56 provide for a further increase of £630,154, and those of 1956–57 for a net increase of £1,023,930. On October 1, 1955, the Department employed 4,379 staff of all grades (including 190 part-time) compared with 4,220 (164 part-time) in the previous year. Annual grants to research associations totalled £1,335,125 (compared with £1,254,088 in 1953–54), grants for special researches amounting to £315,425 (£412,431 in 1953–54). Grants to students amounted to £323,022, an increase of £27,603, the number of students in training in 1954 being 1,052, and in 1955, 1,022, compared with 1,009 in 1953; and of these, 381 in 1954 and 379 in 1955 were new. Of eight senior research awards in 1954 and in 1955, two in 1954 and five in 1955 were new, and 26 new grants for special researches in 1954 and 15 in 1955 brought the total of such grants to 64 and 53, respectively, compared with 58 in 1953 and 70 in 1952. Of the grants for special researches, 37 in 1954 and 33 in 1955 were in physics; for chemistry the figures were 9 and 9; for biology and also for engineering, 6 and 4; and for mathematics and astronomy, 3 and 1. In 1954 chemistry claimed 428 and in 1955, 399 of the students receiving grants; in physics the corresponding figures were 301 and 262; in engineering, 104 and 91; in biology, 97 and 107; in mathematics and astronomy, 60 and 86; in geology and mineralogy, 36 and 42; and in metallurgy, 26 and 23.

Expenditure of £926,971 gross or £556,435 net on the National Physical Laboratory was slightly more than in 1953–54 (£513,049 net), and this is true of expenditure on all branches of the Department's activities, except fire research, which decreased by £2,922 to £22,433; the increase on 1953–54 was, in general, about 10 per cent, apart from the contributions to European Nuclear Research, which increased from £42,483 to £359,787. Expenditure on mechanical engineering research only increased, however, by £1,154 to £315,561. Net expenditure under the other major headings in 1954–55 was as follows, the increase over 1953–54 being given in brackets: building research, £453,049 (£41,455); food investigation, £373,208 (£81,090); road research, £343,516 (£37,984); fuel research, £270,419 (£23,535); geological survey and museum, £223,410 (£12,670); chemical research laboratory, £136,350 (£11,997); forest products research, £116,487 (£15,235); radio research, £107,298 (£12,901); hydraulics research, £76,169 (£14,607); water pollution research, £74,321 (£11,648); pest infestation, £68,145 (£9,388); headquarters administration, etc., £247,915 (£27,536).

The contribution to the European Organization for Nuclear Research was increased to £520,000 in the 1955–56 estimates and further to £930,000 in those for 1956–57, while of the grants for special researches some £250,000 of the total £315,425 is for support of nuclear physics research in universities. This total was increased to £422,200 in the 1955–56 estimates and to £497,000 in those for 1956–57. These grants were provided for the installation and operation of the large particle-accelerating machines for research in nuclear physics in the Universities of Birmingham, Cambridge, Glasgow, Liverpool and Oxford, and the Advisory Council has endorsed the recommendation of the Nuclear Physics Committee for supplementary grants of £7,720 to the University of Glasgow and £14,200 to the University of Liverpool. A grant of up to £82,000 to the University of Manchester for the installation of a 6-MeV. Van de Graaff generator for research on nuclear structure has also been recommended by the Advisory Council.

Although the European Organization for Nuclear Research receives the major part of the Department's contribution to international co-operation, developments during the past year in desalting brackish waters have provided an interesting example of the difficulties as well as the possibilities of international co-operative research. A working party concerned with this subject, after considering a report on existing and potential processes for desalting, recommended that meetings should be called by the Netherlands to discuss electrodialysis with ion-exchange membranes, by the United Kingdom to discuss the prevention of scale formation in distillation equipment, and by France (in Algeria) to discuss solar distillation and certain aspects of ion exchange. Out of these meetings during the current year has come an agreement signed by Algeria (for France), Australia, South Africa, the Netherlands and the United Kingdom.

* Department of Scientific and Industrial Research. Report for the year 1954–55. Pp. 321. (Cmd. 9690.) (London: H.M. Stationery Office, 1956.) 7s. 6d. net.

under which, in return for a share of the development costs, the United Kingdom will have a voice in the development of the process of electrodialysis with ion-exchange membranes in the Netherlands and rights under Netherlands patents. Under a less formal agreement on scale-prevention work, the Department has contributed funds to permit expansion of the existing Admiralty research group, and the Netherlands have provided an additional research worker for the team.

Government Establishments

The Advisory Council's report refers again to the urgent need for a new Fuel Research Station and, as a prelude to planning a new station, has reviewed the policy which should govern the future work of the Fuel Research Organization. As a result, the Council has recommended that the Fuel Research Station should maintain its position as a national centre for the study of fuel problems free from political considerations and pressure of sectional interests; that the Station should aim at becoming the central organization in Britain for long-term basic research on fuel; and that it should not usually undertake applied research beyond the stage at which this can properly be transferred to other organizations engaged on fuel research. On this basis, it recommends construction of a new Fuel Research Station as a matter of first priority, and it is understood that the Ministry of Fuel and Power is in broad agreement with this policy and that the Committee of the Privy Council for Scientific and Industrial Research has adopted these recommendations.

About one-fifth of the total effort of the Station is now applied directly or indirectly towards reducing pollution of the atmosphere by the treatment and utilization of fuels and their products. Semi-automatic equipment for the elimination of smoke has been devised and tested on the Lancashire boiler at the Research Station with satisfactory results, and attention is also being given to coal-fired and oil-fired central-heating boilers with the object of increasing efficiency while decreasing emission of smoke. Work on the removal of oxides of sulphur from boiler flue gas by the use of ammonia has shown that by working the process in two or more stages the sulphur can be recovered as ammonium sulphate with an efficiency of 96 per cent and loss of only 3 per cent of ammonia, and as a result of these experiments the Central Electricity Authority is erecting at the Nottingham generating station a pilot plant to treat 2 million cubic feet of flue gas per hour. After examining the fluidized catalyst process for the Fischer–Tropsch synthesis, attention has been given to the 'liquid phase' or slurry process, in which synthesis gas is bubbled through a suspension of powdered catalyst in heavy oil or molten wax; and studies continued of the changes occurring in residual fuel oils on storage that makes them difficult or impossible to pump, with the view of devising a test that will make it possible to predict the behaviour of a freshly prepared oil. Examination of the industrial processes to which coal is submitted indicated that on carbonization of coals containing 6–10 parts of germanium per million, up to 90 per cent of the germanium remains in the coke, and that the germanium contents of the dusts collected in heating-flues of the coke-burning producer of a coal carbonization plant rose to a maximum of three per cent in the recuperator.

The research stations with the work of which the Advisory Council's report is this year particularly concerned are the Fire Research Station and the Forest Products Research Laboratory. Both were visited by the Advisory Council, which was well satisfied with what it saw. It is convinced that the Fire Research Station is a continuing success. Although administered in detail as a government research establishment, it is a joint organization controlled by the Department and the Fire Officers' Committee, each contributing one-half of the running and capital costs. Under a new agreement recently concluded between the partners, the current annual expenditure will be increased from just under £90,000 to a maximum of £125,000, and the non-industrial staff will be gradually increased from just under 80 to more than 100. Extensive new buildings and equipment are to be provided at a cost of up to £365,000, and one of the new buildings, towards which and towards the general site the Fire Service Research and Training Unit has made a grant of £70,000, will provide facilities for the study of fires in large-scale models under controlled conditions. Work during the year has included an inquiry into the effect of heat on various types of high-tensile steel used in the construction of pre-stressed concrete, and the development of a new roof test and a new test for combustible wall linings; and a committee has been established to advise on a research programme on industrial fires and explosions.

Some 35 per cent of the staff effort at the Forest Products Research Laboratory (and also at the Building Research Station) is at present devoted to advisory and related work—a proportion which the Advisory Council regards as too high, and it hopes that the industrial research organizations will in future relieve the Laboratory increasingly of this type of work, leaving it freer to conduct more fundamental investigations. In particular, the Research and Information Committee of the Furniture Development Council and the Research and Development Committee of the Timber Development Association are expected to assume increasing responsibility for applied research in this field. Work during the year has included experiments with growing English ash which indicated that the degree of lignification of the fibre walls (which affects the strength of wood) is at least partly controlled by the illumination received by the leaves. A series of tests of the moisture gradient of wood carried out over a year indicates that where, as in boats or vats, the wet face cannot be painted, the dry face should also receive no paint, or at most only a thin pervious coat. Estimates of the strength of laminated timber have been extended to the study of beams from two different species, and research is being carried out on the permeability of woods to liquids and gases, on the factors that govern the susceptibility of various zones of Corsican pine to infestation by the furniture beetle and the house longhorn beetle, and on the bending vibration and damping of wooden beams and rectangular plates.

The proposals for the organization of practical trials in collaboration with the National Federation of Building Trades Employers met with a good response from the members, and a series of trials with aerated mortars has been completed, while the Building Research Station has also made good progress in developing a process for the production of light-weight aggregate from pulverized fuel ash. In designing large rigid frames, the main problem is to find a method which is sufficiently accurate while avoiding heavy design costs. It has now been shown

that the behaviour of a frame to be designed can be deduced by reference to an idealized substitute frame which has already been analysed, and a new method of design for stanchions is being developed which will lead to further economy. Particular attention is being paid to the problem of measuring the stress in the linings of deep tunnels in clay and, as a result of the work on schools which has continued for some five years in collaboration with the Ministry of Education architectural development team and the Hertfordshire County Council, a body of essentially new information has been made available to designers, in terms of which they have been able to plan for fuel economy and design economy in schools.

Commenting on the work of the Chemical Research Laboratory, the Advisory Council expresses the opinion that the present programme of the Laboratory is well chosen and that, although the Laboratory's work on semi-permeable membranes, including membranes with ion-exchange properties, is limited, it has already made important contributions and should be continued and if possible extended. During the past year the trades concerned have been steadily brought into closer contact with the preparation of the Food Investigation Organization's programme and its work and, in the Fish Division in particular, close liaison has been effected with the White Fish Authority and the Herring Industry Board. The trawler *Northern Wave* has been chartered for a joint experiment in freezing at sea on a commercial scale, and special attention is being given to research on smoke-curing with the view of developing more convenient, controllable and economical procedures and of producing cures of white fish and herrings of consistently high average palatability and keeping quality. Plans have been drawn up for an experimental unit to be attached to a new centralized abattoir, and studies of fresh and frozen beef have continued. Recent storage trials have indicated that pears could be kept for longer periods at 30–31° F. without suffering low-temperature injury, and work is also being continued on the effect of field factors on the chemical composition and storage life of apples. A coating of sulphonated polystyrene on diatomaceous earth has proved valuable in the chromatographic purification of insulin and a similar method has been developed for purifying meat myoglobin.

The Geological Survey has made continuous progress since the War with the primary six-inch survey, which is the basis of all Geological Survey work, and with the first six-inch re-survey of areas of economic importance; it has also re-published ninety-two one-inch to the mile maps in colour-printed editions and extra editions of ten other maps printed to show solid geology only, making a total of 102. But only four of the twenty-four quarter-inch geological maps of England and Wales have been re-published and nineteen of the sixty-two one-inch sheets of Scotland, with fourteen additional sheets showing drift geology. All ten of the seventeen quarter-inch geological maps of Scotland published before the War have been reprinted. The Geological Survey has also statutory obligations under the Mining Industry Act (1926) and the Water Acts of 1945 and 1946, while the Museum of Practical Geology, which again had a record number of visitors (374,353), has acted as a study centre for geological research and exhibition of collections of minerals, gem-stones, rocks and fossils. During 1954, 270 square miles in Great Britain were covered by primary six-inch survey, and 253 square miles, including 75 square miles in Northern Ireland, by revision survey. Boreholes drilled during recent years continued to provide much material calling for specialized petrological investigation, and during 1954 more than eight hundred boreholes were notified to the Geological Survey under the terms of the Mining Industry Act and more than 300,000 ft. of strata were examined, identified and described. The Survey itself is drilling four boreholes in the Ashover district north-east of Matlock to ascertain the sequence and structure of the Millstone Grit and higher parts of the Carboniferous Limestone between the Derbyshire coalfield and the limestone country west of Matlock. The task of encouraging the search for the mineral raw materials necessary for the Atomic Energy Authority's programmes remains with the Atomic Energy Division of the Geological Survey, and besides further searches for uranium, attention is being given to a search for thorium deposits and to the development of new methods of geophysical and geochemical prospecting, particularly to fundamental research as to the most profitable lines for conducting geological exploration.

The work of the National Physical Laboratory and the Chemical Research Laboratory for the period have been reviewed in these columns fairly recently, so no more need be added here than that the Digital Electronic Universal Computing Engine (Deuce) was installed early in 1955, and the construction of the final Automatic Computing Engine started. The High Temperature Fatigue Laboratory has now been transferred to the Mechanical Engineering Research Laboratory, the staff of which increased by 13 per cent during the year. Two further symposia, dealing with precision electrical measurements (November 1954) and boundary layer effects in aerodynamics (March 1955), have been held in the National Physical Laboratory.

The first stage of the main hall of the Hydraulics Research Station was completed in January 1955 and arrangements have been made with river boards and coast protection authorities to collect data on beach movements and all matters bearing on coastal protection; analysis of these observations will provide valuable information on long-term trends of erosion or accretion. The investigation into the behaviour of storm surges in the Thames Estuary has been extended to examine the effect which a barrage would have in reducing storm surges of various magnitudes, and the large model of the River Thames is being used for investigating the general pattern of estuarine circulation and its relation to the tendency for serious silting to occur in the so-called "Mud Reaches" immediately downstream of the Royal Docks. A model of the tidal reaches of the River Trent is being constructed. A second model has been built in connexion with the Severn River Board's scheme for the relief of flooding on the River Severn; this includes 24 miles of the river downstream from Shrewsbury to Buildwas, and it is being used for ensuring that the reduction of floods in the neighbourhood of Shrewsbury will not lead to more serious flooding elsewhere along the river. Basic experiments in the 54-ft. wave tank have indicated that a screen of spaced piles offshore from a sand beach did not cause the beach to build up but halted or almost halted erosion, and two-dimensional wave tests have been carried out for the Kent River Board on a model of a section of the proposed Dymchurch sea wall. The proposed design of a new harbour to

be constructed at Tema on the Gold Coast is being investigated in Wave Basin No. 2.

Biological research in the Pest Infestation Laboratory included field-work on residual populations of insects in farm buildings, in an old watermill and in disused dock storage sheds. Research on grain storage was largely confined to the experimental storage of damp grain in airtight silos; that on insecticides included a new method for the chemical assay of pyrethrins, the control of bean weevils with insecticidal dusts, the mechanical protection of goods from infestation by sheeting, and the relative susceptibility of different insect species to pyrethrins. Long-range biochemical work was concerned with the nature and significance of insecticide residues in foodstuffs and mechanisms of insecticidal action.

In the Radio Research Organization the main emphasis continued to be on the factors which affect radio waves during transmission between the transmitting and receiving stations; but the importance of the work on semiconductors and on ferromagnetic materials is also stressed, the former being concerned with noise generation in germanium and components made from it and with measurements on transistors. In the field of navigational aids, the main interest is in low-frequency and very low-frequency position-fixing applications and, at higher frequencies, in radio direction-finding.

A main group of researches carried out by the Road Research Laboratory seeks to provide road engineers with the basic information needed for decisions as to the most satisfactory and economical types of road construction for particular conditions of soil, traffic and climate; and the Ministry of Transport and Civil Aviation's programme of new road construction will provide the necessary opportunities for full-scale experiments. A scheme has been introduced by which the results of research are embodied in agreed specifications for use on selected sites under conditions of good normal commercial practice. Evidence is accumulating that the separation of motor traffic from other road users decreases accidents, and a study has been made of eighty-six sites reported as the scene of repeated skidding accidents. The Laboratory's work on non-destructive tests for measuring the strength of concrete by an ultrasonic pulse technique has been summarized and the equipment required is now being manufactured.

The new Water Pollution Research Laboratory at Stevenage was officially opened on June 20, 1955, and investigations in progress include a detailed study of the effects of pollution on rivers and estuaries, fundamental work on processes of sewage treatment and the investigation of methods of treating industrial waste waters. Progress was made in studying the oxygen balance of the Thames Estuary and in attempts to predict the effect of polluting discharges on the content of oxygen in the estuary water. Observations on the effect of sewage effluent on the River Colne near Watford have been completed, and tests with seven popular proprietary washing powders indicated that 50 per cent of rainbow trout were killed in about seven days in a solution containing the equivalent of rather less than 6 p.p.m. sodium dioctylsulphosuccinate.

The work of the Intelligence and Information Division of the Department is mostly directed towards the improvement of industrial productivity, and altogether a programme of twenty-nine projects concerned with human factors in industry and costing more than £155,000 from Conditional Aid Funds is guided by the two joint committees of the Department and the Medical Research Council and serviced by the Division. Most of the projects are being carried out by the universities, independent research institutions or research associations; but one concerned with problems of work study, including those of introduction, such as the reasons for suspicion and resistance, the assessment of results in terms of the impact on efficiency and human relations within firms, and problems of continuing application, is being undertaken within the Division. Work has continued on the sample survey of research expenditure of private industry, and an economist was appointed to help the Food Investigation Organization and the Pest Infestation Laboratory assess the economic relevance and application of their current work. The Industrial Operations Unit has demonstrated the value of a more systematic study of industrial operations, particularly of improved methods of planning and controlling work, and a survey has been initiated of technical developments leading to automatic processes in industry and of the broad economic and social implications of these developments. During the year, following successful pilot-plant trials of a suggestion that effluents might be treated with ammoniacal liquors from gas works to produce ammoniacal sulphate and a hydrated iron oxide, the Gas Council decided to erect a full-scale plant. The iron oxide will be mixed with peat and used for sulphur recovery, and besides reducing imports of bog iron ore the new process will reduce the demand of the gas industry for sulphuric acid.

(*To be continued*)

CHROMATOGRAPHY AND PARTITION OF CELLS AND CELL FRAGMENTS

By PER-ÅKE ALBERTSSON

Institute of Biochemistry, University of Upsala

THE study of isolated cell particles has given much information about the organization of the cell. The method which is generally used for fractionation of the particles from a homogenate is differential centrifugation. In that method, differences in the sedimentation velocities of the particles are utilized for their separation, and differences in sedimentation velocities depend mainly on differences in size, density and form of the particles. Ultracentrifugation in density gradients has also been used for the same purpose. Here the difference in particle density is the determining factor. It should be possible, however, to utilize differences in other properties, too; for example, physical and chemical properties of the surface and the electrical charge of the particles.

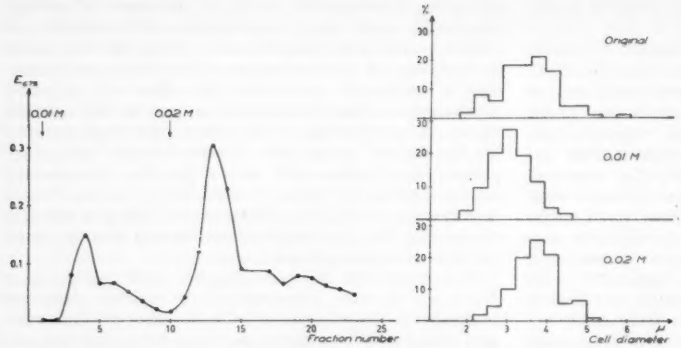

Fig. 1. Chromatography of *Chlorella pyrenoidosa* on calcium phosphate. Left: the two peaks which are obtained by elution with 0·01 *M* and 0·02 *M* phosphate buffer *p*H 7. Right: distribution polygons of cell diameters in the original suspensions and the two elution peaks. Temperature, + 4° C.

These properties, among others, determine the adsorption behaviour of the particles on an adsorbent, which means that it should be possible to apply the method of chromatography. Further, these properties determine the affinity of the particles to the two phases of a liquid–liquid system, which means that fractionation could be performed by partition. This article will describe some experiments which have been carried out in order to apply these two methods to cells and cell particles.

Chromatography. Tiselius[1] refers to the successful chromatography of proteins of high molecular weight[2], viruses[3] and cytoplasmic granula[4] and points out that the upper limit of the size of the particles to be chromatographed has not yet been reached. Recently bacteria have been chromatographed[5], and human platelets have been concentrated by an adsorption technique[6].

When an attempt is made to chromatograph cells and cell fragments many practical difficulties are encountered. Often the particles have a tendency to aggregate on the adsorbent or to be irreversibly adsorbed by it. In addition, due to their size (usually 0·1–10μ) the particles often cannot pass through the pores of the adsorbent. This latter problem, however, can be solved by one of the three following procedures.

The first and simplest one is to use an adsorbent with very large grains compared with the particles to be chromatographed. It has thus been possible to use a very coarse calcium phosphate preparation from ignited bones according to W. F. Anacker (personal communication) for the chromatography of *Chlorella pyrenoidosa* Pringsheim. A suspension of the algae from a conventional culture was allowed to pass through an ordinary column packed with this calcium phosphate. The cells were adsorbed and could then be eluted by step-wise increase in concentration of phosphate buffer *p*H 7 [2]. The amount of *Chlorella* in the different fractions was followed by the extinction at 675 mμ measured in a Beckman *DU* spectrophotometer. As is seen from Fig. 1, peaks were obtained for 0·01 and 0·02 *M*. Fractions from these were analysed in the microscope and the cell diameter was measured. As is seen from Fig. 1, larger cells have been eluted at higher phosphate concentrations. It was found, too, that the concentration of dividing cells was about ten times higher in the 0·02-*M* peak. There was no significant difference in cell diameter between fractions within a peak.

Fig. 2

This experiment suggests that chromatography can serve as a method for obtaining more uniform suspensions of micro-organisms. It has also recently been demonstrated by Maruyama and Yamagata[5].

The second method is to work batchwise by shaking the suspension with the adsorbent, allow the latter to sediment, then decant the supernatant and eventually make this procedure continuous, as is done in Craig's counter-current extraction. In this way a suspension of disintegrated *Chlorella*, obtained by vibrating a suspension in the Mickle disintegrator[7], was shaken with 'Dowex 3' at *p*H 6·5 (0·2 *M* phosphate). All particles except the starch particles were adsorbed. After these had been washed away, the cell walls could be eluted in a very pure state by changing the *p*H to 7·5.

The third alternative is to perform the separation in a column in which the adsorbent grains steadily move so that the particles to be chromatographed can penetrate the column. The ideal movement of the adsorbent should then be such that mixing of the grains occurs only within thin horizontal layers (see Fig. 2). In practice, however, a vertical mixing between the layers is difficult to avoid, so that an adsorbent grain 'diffusion' takes place which will cause broadening of zones. Despite this disadvantage, a column has been constructed according to this

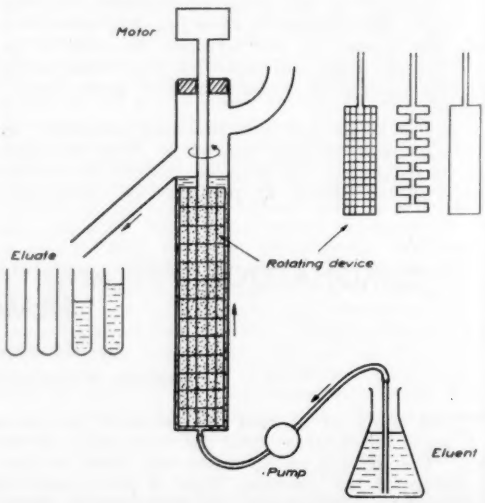

Fig. 3. Chromatography column with rotating adsorbent layers. The rotating device can have one of the indicated forms (upper right). The two to the right are made of 'Plexiglass'; the one to the left, which is the most effective, is made of a net of metal wire

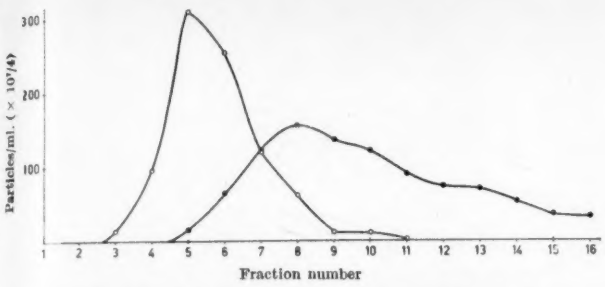

Fig. 4. Chromatography of disintegrated *Chlorella pyrenoidosa* on calcium phosphate. Elution of cell walls and starch particles with 0·2 *M* phosphate buffer, *p*H 7. Temperature, + 4° C.
○, cell walls; ●, starch grains

principle (see Fig. 3). It is made of 'Plexiglass' and provided in the centre with a rotating device which can have different shapes and is driven by a motor (4 revs. per min.). This rotation makes the adsorbent grains move around mainly horizontally. The solvent is introduced at the bottom by means of a pump (about 8 ml. per hr.). Ascending flow is preferred in order to make the packing of the adsorbent weaker and hence the resistance against the rotation smaller. The eluate is collected through a side tube into a fraction collector. A suspension of disintegrated *Chlorella pyrenoidosa* in 0·2 *M* phosphate buffer was pumped through such a column packed with a fine-grade calcium phosphate preparation, according to Ö. Levin (personal communication). In the eluate cell walls and starch particles appeared. In each fraction the number of these particles was counted in a counting chamber. The result is shown in Fig. 4, where the concentration of each particle is plotted against fraction number.

Table 1. Partition of some Cells and Cell Fragments in the Two-phase System Water/Potassium Dihydrogen and Dipotassium Hydrogen Phosphate/Polyethyleneglycol 4000

Particles	System I*	System II†
Serratia marcescens	*B*	
Chromobacterium sp.	*B*	
Corynebacterium sp.	*B*	
Nocardia sp.	*T*	
Ophiostoma multiannulatum	*B*	*I*
Chlorella pyrenoidosa	*B*	*I*
Disintegrated *Chlorella*:		
Chloroplast fragments (microscopic)	*I*	*I*
Chloroplast fragments (submicroscopic)	*T*	*T*
Cell walls	*B*	*I*
Starch grains	*B*	*B*
Spinach chloroplast	*I*	
Starch grains and fragments of cell wall of spinach	*B*	

*I = 79·6 per cent H_2O; 10·5 per cent KH_2PO_4 + K_2HPO_4; 9·9 per cent polyethyleneglycol (per cent by weight).

†II = 77·3 per cent H_2O; 13·9 per cent KH_2PO_4 + K_2HPO_4; 8·8 per cent polyethyleneglycol.

B = Bottom phase. *T* = Top phase. *I* = Interphase

Partition. According to Brönsted[8], the higher the molecular weight of a substance subjected to partition between two liquid phases, the greater the quantity which tends to go into one of the phases. While one can still measure finite partition coefficients for proteins[9], the coefficient for a cellular particle, which has a very high 'molecular weight', will be either zero or infinite. This means that if a liquid–liquid system is shaken with a suspension of identical particles, we should find all these, according to Brönsted's theory, either in one phase or the other. In practice, however, adsorption occurs in some cases on the interphase between the two phases. This phenomenon can be explained if it is looked upon from the point of view of surface tension. Depending upon the values of the interfacial tensions between a particle and the two phases and the interfacial tension between the two phases, the particle will be stable either in one of the two phases or at the interface[10].

The system which has been studied in order to apply these phenomena to fractionation of cellular particles is water/a mixture of potassium dihydrogen plus dipotassium hydrogen phosphate, *p*H 7/polyethyleneglycol 4000 ('Carbowax'). At certain concentrations this system will give two liquid phases similar to those systems which have been used for partition chromatography of proteins[11]. Some whole cells and disintegrated cells have been shaken with this system and their partition is shown in Table 1. At the composition I of the system (see Table 1), *Chlorella pyrenoidosa*, for example, goes to the bottom phase. If the system is changed to composition II, most of the cells are found at the interface. This process is reversible. If disintegrated *Chlorella pyrenoidosa* are shaken with the system at composition I, large fragments of the chloroplasts go to the interface, the smaller ones to the top phase, while the cell walls and starch particles go to the bottom phase. If now the bottom phase is separated and the particles in it are shaken with a system of composition II, the cell walls go to the interface. Fig. 5 is a photomicrograph of cell walls isolated in this way.

In the experiment with spinach chloroplasts, a suspension of whole chloroplasts was made by conventional differential centrifugation. The chloroplasts went to the interphase while starch particles and fragments of cell wall went to the bottom phase. Thus particles with similar sedimentation velocities have been separated.

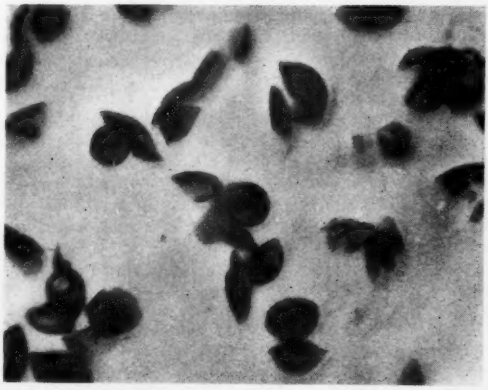

Fig. 5. Isolated cell walls of *Chlorella pyrenoidosa*. Phase contrast, stained with crystal violet. × 2,000

A detailed report of this work will be published elsewhere. I wish to thank Prof. A. Tiselius for his interest and advice. [Feb. 11

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OBITUARIES

Dr. F. Sherwood Taylor

The death of Dr. Frank Sherwood Taylor, director of the Science Museum, on January 5, at the early age of fifty-eight, has removed from the scientific life of Great Britain one whose interests transcended the narrow limits of his original specialist studies in chemistry and who had become widely known as a historian of science and as a very skilful expounder of the intricacies of modern science to the layman.

Born on November 26, 1897, Taylor was educated at Sherborne and at Lincoln College, Oxford, where he was elected to a classical scholarship. The First World War interrupted his studies and deflected his interests from classics to chemistry. After graduating, he taught chemistry at various schools, including Gresham's and Repton, and during 1933–38 he was assistant lecturer in chemistry in Queen Mary College, London. In the meantime, he had obtained the degree of Ph.D. in the University of London for his historical researches on Greek alchemy as the first student in the newly established Department of the History and Method of Science in University College. In 1940 he became curator of the Museum of the History of Science, Oxford, where he remained until he was appointed director of the Science Museum, London, in 1950.

Sherwood Taylor, as he was generally known, was always deeply interested in alchemy and the alchemists; he would spare no pains in attempting to understand the most obscure writers and in trying to explain their words in more familiar and comprehensible terms. It was with the greatest enthusiasm, therefore, that he took a most active part in founding in 1937 the Society for the Study of Alchemy and Early Chemistry and in acting as honorary editor of its journal, *Ambix*, from its first appearance in 1937. A similar enthusiasm marked his support of the British Society for the History of Science when it was founded in 1947, and he served the Society as president during 1951–53.

Apart from many papers in specialist journals, such as *Ambix* and the *Annals of Science*, Taylor wrote extensively on the history of science, on chemistry and on alchemy, and also on religious topics. His earliest books were text-books of chemistry, and these were marked by a clear and attractive style as well as by the high standard of presentation of the material. He will, however, be best remembered for his books on the history of science: "Galileo and the Freedom of Thought" (1938), "A Short History of Science" (1939), "The Century of Science" (1940), "Science Past and Present" (1945), "The Alchemists" (1952), "An Illustrated History of Science" (1955), embodying the Christmas Lectures that he gave at the Royal Institution in 1953, and "A History of Industrial Chemistry" (1955). To the general reader he was also known for his remarkable presentation of modern science in "The World of Science" (1936), a work of more than a thousand pages that has retained its well-deserved popularity after the lapse of twenty years.

In the later part of his life Taylor was received into the Roman Catholic Church. He was always deeply concerned in religious matters, although not given to parade his views. Those who had known him long were aware of a strong mystical element in his thought. His writings on religion include "The Fourfold Vision" (1945) and "Two Ways of Life" (1947). His scholarship, his tolerance, his gentle ways, his regard for science as part of man's cultural heritage will long be remembered. Few of those who recall him will know that he was severely wounded at Passchendaele on October 10, 1917, while serving with an infantry unit of the Honourable Artillery Company, and fewer still know that he was at the time voluntarily taking the place of an older man.

Douglas McKie

Dr. E. W. Gudger

The death occurred on February 19 of Dr. Eugene Willis Gudger, one of the oldest staff members of the American Museum of Natural History; Dr. Gudger would have been ninety in August.

Dr. Gudger was born on August 10, 1866, in the mountain section of North Carolina, the son of a circuit judge. Both his parents were descendants of the British settlers of that area and he was very proud of the fact that the name Gudger had originally been Macgregor. He was educated at southern schools and took his doctorate at Johns Hopkins. He then taught general science, first in a secondary school in Little Rock, Arkansas, where his pupils were little younger than he, and then for twenty-five years in the North Carolina College for Women. For many years he went to reunions of the Little Rock class he had taught, and some of his old pupils there remained his closest friends.

In 1919, Dr. Gudger went to the American Museum of Natural History to edit the third volume of Bashford Dean's "Bibliography of Fishes", and after Dr. Dean's death, in 1928, took on the difficult task of editing the Dean Memorial volumes, and was in charge of the Dean Memorial Library and of the card catalogue which until 1938 continued the Bibliography.

In 1921 he was appointed associate in ichthyology, and in 1935 this title was changed to the regular staff appointment of associate curator of fishes. In 1938 Dr. Gudger became one of the honorary staff of the Department of Fishes, but continued as librarian of the Dean Memorial Library. In 1952, his age and

his failing eyesight compelled him to stop work at the Museum and he retired to his former home in Waynesville, North Carolina, where he died.

Dr. Gudger's bibliography was enormous: chiefly articles on odd facts about fishes, old natural history myths and the distribution and habits of the whale shark. He was primarily a library worker, with an extraordinary knowledge of ancient natural history literature. He conducted a vast correspondence on all sorts of topics, ranging from fishes to inaccuracies in magazine illustrations of steam engines. The arrival of his mail and his southern home-town paper brought him to the Museum early every morning before the main doors were open or the corridor lights on.

Dr. Gudger was an impressively tall, rosy-cheeked, silver-haired man with peering, bespectacled blue eyes. Due to his unusual appearance, his determined and emotional personality—as booming in enthusiasm as in anger—his departure from the Museum deprived us of one of our most colourful figures.

Dr. Gudger never married. He is survived by a brother.

F. R. LaMonte

Prof. J. R. H. Whiston, O.B.E.

Prof. J. R. H. Wh.ston, head of the Applied Chemistry Branch in the Royal Military College of Science, died on February 28 after a short illness.

John Reginald Harvey Whiston was born at Gonalston on January 3, 1893, and attended Nottingham High School during 1902–11, when he obtained an open Exhibition in Natural Science at Jesus College, Oxford, where he obtained a first in chemistry in 1914. During the First World War he served (1914–16) as an officer in the Sherwood Foresters, and from 1916 to the end in the R.F.C. as an experimental officer in the Seaplane Experimental Establishment at Martlesham Heath.

In 1919 Whiston returned to Oxford as a demonstrator in the Jesus College Laboratory, where he worked with the late D. L. Chapman on the hydrogen–chlorine reaction, particularly on the effect of oxygen, and with Sir Henry Tizard on indicator problems. After two further years in Oxford as a research chemist to the British Dyestuffs Corporation, he joined the staff of the Military College of Science at Woolwich in 1922.

The remainder of Prof. Whiston's career was spent in the Royal Military College of Science—he became an associate professor in 1936 and stayed with the College throughout its travels from Woolwich to Lydd, from Lydd to Stoke and from Stoke to its new permanent home in Shrivenham. At first his work was mainly on lubricants and on the improvement of petrols; but later he specialized more on Service explosives, and several government publications, including part of the new Services text-book of explosives, were written by him. In 1946 he was made O.B.E.

Prof. Whiston built up, in the College and outside, a reputation as an outstanding teacher and administrator, and he will be long remembered by the students, more than two thousand in number, who were taught by him. The staff of the College will always be grateful to him for his long labours on their behalf in official negotiations and for his never-failing help and kindness to the junior members. He is survived by his widow, their married daughter, and by two grandchildren.

E. C. Baughan

Mr. John Pryce-Jones

The unexpected death of John Pryce-Jones, so soon after his retirement because of ill-health, came as a profound shock to his many friends. He had been in indifferent health for some time, and early this year he had to undergo a major operation.

Pryce-Jones, who was sixty-two years of age, was born in Pencader, and was educated at Llandyssul Grammar School and the University College of Wales, Aberystwyth. He belonged to an age which thought of university education as a great privilege, and throughout his life he maintained the academic interests of a true scholar while engaged in the chemical and administrative affairs of a prosperous industrial firm. After service in the R.N.V.R. as a meteorologist at Scapa Flow during the First World War, he joined the staff of Reckitt and Sons, Ltd., in 1919, and he remained with Reckitt and Colman, Ltd., until his retirement last September. During this time he became known as a leading expert on the manufacture and uses of ultramarine blue, and in 1950 he was appointed a director of Reckitt's (Colours), Ltd., when that company was formed.

Pryce-Jones was interested in all aspects of the chemistry of ultramarine, and among his fine collection were specimens of many shades. In particular, he was interested in its structure and in the influence of particle size, and he made important contributions to the improvement of the manufacture and application of this unusual material. His interest in lapis lazuli was such that he acquired a deep knowledge of its uses in medieval times, and he had a remarkable knowledge of art, in particular of the pigments used in paintings. He was an accepted authority, too, on oils and paints, and was keenly interested in oil paintings and in methods used in the faking of old masters.

During the nineteen-thirties, Pryce-Jones began to develop his interests in rheology, and his papers in the *Journal of the Oil and Colour Chemists' Association* on this subject were soon recognized as having more than a technical importance. They were, indeed, the beginning of a series of studies in the field of rheology which he continued up to the time of his death, and they constituted a very considerable contribution to knowledge.

Pryce-Jones was especially interested in the various modifications of the phenomena associated with 'thixotropy', and he designed several instruments for their investigation. He was strongly of the opinion that there are two distinct modes of behaviour involved in reversible loss of consistency as a result of shearing, corresponding to lyophobic and lyophilic colloidal conditions, respectively. He differentiated clearly between 'thixotropy' proper and 'false-body', though admitting that these can occur together in mixed systems. His nomenclature was sometimes unusual, but always lucid; for example, he insisted that any measurable rigidity should indicate the use of the term 'gel', the term 'sol' being strictly reserved for liquids. He designed an ingenious 'double Couette' viscometer consisting of two concentric cylinder instruments in series, with which he studied many rheologically anomalous materials. His work as an industrial chemist led him to take as wide an interest in suspensions as in sol–gel systems.

Pryce-Jones was one of the first to observe the phenomenon now generally named after Weissenberg (when a material climbs up a vertical rotating rod), which he characteristically referred to as the

"Mae West Effect". As a result of his work on the thixotropy of honeys from certain floral sources, he became a leading authority on honey in general, and he wrote with considerable insight and knowledge about honey and about bee-keeping.

He was a fascinating lecturer and speaker, and both in Great Britain and abroad he had given lectures to various societies on his different specialisms. He had not only a great facility for explaining intricate problems to specialists, but also the ability of giving a simple, and yet scientifically accurate, picture to the layman. He was an omnivorous reader and bibliophile, and he could always be relied upon to make an illuminating contribution to any discussion.

His passing is a great loss to science, for he did much to stimulate scientific interests, particularly in the East Riding of Yorkshire. He was a former chairman of the Hull Branch of the Oil and Colour Chemists' Association and a past president of the Hull Chemical and Engineering Society.

He will be sadly missed at the meetings of scientific bodies and by his innumerable friends and associates in every walk of life: he was perhaps the perfect mixer.

He married, in 1921, Miss Helen Bune, who survives him. Their only son was lost in a tragic accident some years ago.

Paul G. 'Espinasse
Brynmor Jones

NEWS and VIEWS

Geological Survey of New Zealand : Dr. L. I. Grange

Dr. L. I. Grange has retired from the post of director of the Geological Survey of New Zealand. Dr. Grange was born at Castlecliff, Wanganui, and in 1913 he won from Waihi School of Mines a Mines Department scholarship to attend the University of Otago. After war service in France during the First World War and further study at the University, he joined the N.Z. Geological Survey. Dr. Grange's professional career can be divided into three main phases: his work as a volcanologist in the Central North Island, his career as a pedologist culminating in his directorship of the Soil Bureau, and his return to the Geological Survey as director. For the Central North Island his bulletins on the geology of the Tongaporutu–Ohura and Rotorua–Taupo districts still remain authoritative publications. The last-named bulletin is a particularly important contribution to the world's knowledge of thermal activity. As a result of his work on soils, Dr. Grange became leader of a soil survey section of the Geological Survey, and in 1935 he was appointed director of a newly-formed Soil Survey Division. In 1940 he initiated a 4 miles/in. survey of the North Island, and followed this up by applying the results of the survey to practical problems. By 1946 physicists and biologists had been added to the soil team, and the Division was renamed the Soil Bureau. Later he extended his work beyond New Zealand to tropical soils in the Pacific Islands, where soil use in relation to population and food supplies is a problem. In 1952 Dr. Grange returned to the Geological Survey as director. During his term of office he has renewed his early interest in volcanology, and has compiled a departmental bulletin on "Geothermal Steam for Power in New Zealand", which gives a full picture of the work so far carried out in Wairakei. He recognized the probable impact on New Zealand of the important discoveries of radioactive minerals in Australia and after a visit to that country prepared and published a booklet, "Prospecting for Radioactive Minerals in New Zealand". In geology, soil surveys and soil conservation, Dr. Grange has made a notable contribution to New Zealand, and to the welfare of its people.

Mr. R. W. Willett

Mr. R. W. Willett has been appointed director of the New Zealand Geological Survey in succession to Dr. L. I. Grange. Mr. Willett was born in Dunedin in 1912. He was educated at Otago Boys' High School, the University of Otago and the Victoria University College. He joined the Geological Survey in 1936; he served as district geologist at Invercargill during 1942–48, and geologist-in-charge of the Coal Survey Section at Wellington during 1948–51. During 1951–54 he was seconded to the British Commonwealth Scientific Office (London) as liaison officer, and was the first to hold this office. Since returning to New Zealand he has been administrative assistant to Dr. Grange. Mr. Willett has published many scientific papers both in New Zealand and overseas. While in the United Kingdom he prepared a series of papers on the mineral resources of the British Commonwealth, and in 1954 was awarded the Silver Medal of the Royal Society of Arts for his paper on mineral resources of the British Commonwealth. His work in New Zealand has taken him into much of the mountain country of the South Island. He is at present foundation president of the Geological Society of New Zealand.

Zoology at Calcutta : Prof. J. L. Bhaduri

The sudden death of Prof. H. K. Mookerjee in August 1955 left vacant a key post in zoological education in India. This has now been filled by the appointment to the Sir Nil Ratan Sircar professorship and head of the Department of Zoology in the University of Calcutta of Dr. J. L. Bhaduri, a former student of the University. There he graduated B.Sc. with first-class honours in zoology in 1924, and M.Sc. two years later. After two further years, as teaching assistant, in the Zoology Department, he joined the Zoological Survey of India in 1929, and gained valuable field experience, under the guidance of Dr. Baini Prashad and the late Dr. S. L. Hora, in faunistic surveys in the Andamans and in studies of the frogs and toads of the Khashi Hills in Assam. In 1933 he was recalled to his old University as assistant lecturer, and there with increasing responsibility he has combined his recognized skill in teaching with enthusiasm for research. Dr. Bhaduri's main investigations have been concerned with Amphibia Salientia, their systematics, structure and ecology. He studied for two years in the Zoology Department of the University of Edinburgh, and the thesis on "The Urinogenital System of Salientia", for which he obtained the degree of D.Sc. in that University in 1947, contained, among other matters, a revealing correlation between structural modifications in the genital system and

unusual breeding habits in certain species which no longer deposit their eggs in water. His latest field survey (1954) has been a special study of the Salientia in the region of the Western Ghats. Apart from his amphibian researches, he has published papers dealing with mollusca, fishes, reptiles and birds. With his forceful personality, boundless energy, and enthusiasm for teaching and research, the appointment of Dr. Bhaduri promises well for the future of zoology in the University of Calcutta.

Zoological Society of London: Mr. R. N. Fiennes

MR. R. N. FIENNES, senior lecturer in animal health and veterinary science in the University College of the Gold Coast, Achimota, has been appointed animal pathologist to the Zoological Society of London, and is expected to take up his new duties in September. Mr. Fiennes will be responsible for the post-mortem examination of animals which die in the Zoological Gardens, and he will also carry out research in animal pathology. Mr. Fiennes was educated at Winchester and Magdalene College, Cambridge, and at the Royal (Dick) Veterinary College at Edinburgh, and served for some twenty years in the Colonial Veterinary Service, in Uganda and Kenya. He has published a number of papers on trypanosomiasis, and has also worked on other protozoans, on helminths, bacteria and viruses. His appointment is yet another indication of the importance which the Zoological Society places upon the scientific study of animal health.

New Fellowship at University College, Oxford

IN 1954 Mr. James George Weir, C.M.G., C.B.E., gave to University College, Oxford, £25,000 to found a fellowship in memory of his son, Colin Weir, to be devoted to the study of politics with special reference to international affairs. He has now presented to the College a further sum of £25,000 to found an additional fellowship which will be devoted to the study of one of the natural sciences. The fellowship may be given for purposes of teaching or research, or both, and will be known as a Weir Fellowship. The College intends to make an election, if possible, in time for the next academic year.

Swimming-Pool Reactor at Harwell for the Study of Shielding Problems

A RESEARCH reactor of the 'swimming-pool' pattern, named LIDO, is at present under construction at the Atomic Energy Research Establishment, Harwell, and a model of it is included in the display by the United Kingdom Atomic Energy Authority at the British Industries Fair in Olympia, London. The reactor is specifically designed to enable shielding problems to be investigated; hitherto relatively little effort has been made to minimize shielding size and weight, although this is a problem of great importance in the design of mobile reactors and also in keeping down the capital cost of power-station reactors. LIDO is of the thermal type, employing enriched uranium as fuel and light water as both moderator and coolant. The core is suspended in a tank of water from a trolley which enables it to be moved to any part of the tank. Sufficient depth of water is maintained over the core to provide vertical shielding, and horizontal shielding is effected by the concrete walls of the tank. In two areas, one of which is a corner of the tank, the concrete is cut away and replaced by aluminium 'windows'. These form the working faces to which experiments can be built up adjacent to them on the outside, and when measurements are to be made, the core can be moved closer to them on the inside. Experiments can also be assembled inside the tank, and for this the core can be moved into a small bay at one end of the tank and isolated from it by a watertight door. The reactor is due to be completed towards the end of this year.

International Geophysical Year

DURING the forthcoming International Geophysical Year (July 1957–December 1958) certain days have been designated as Regular World Days, and during these periods special observations will be made at frequent intervals. In addition, there will be Special World Intervals, chosen at shorter notice, to coincide with expected unusual magnetic, ionospheric and auroral activity, etc. In order to estimate how many organizations wish to be sent the 'alert' signal so that they are ready to make special observations of any unusual phenomena, it is requested that the names, addresses and telephone numbers of the persons directly responsible for the measurements, in Great Britain and Colonies, should be sent to the Assistant Secretary, Royal Society, Burlington House, London, W.1, as soon as possible, so that the matter can be considered by the British National Committee for the International Geophysical Year.

Marlow Medal of the Faraday Society

THE Faraday Society has instituted a new award, to be known as the Marlow Medal, which, together with a grant of not more than fifty pounds, will be made annually for work over the preceding three years on any subject normally (but not necessarily) published in the *Transactions* of the Society. The Medal is restricted to members of the Faraday Society not more than thirty-two years of age. Applications for the first award should be made before January 1 next to the Faraday Society, 6 Gray's Inn Square, London, W.C.1.

Atoms for Peace Awards

LAST year, at the suggestion of Mr. Henry Ford II and his two brothers, the Ford Motor Company Fund made an appropriation of a million dollars to be used for granting each year for ten years an Atoms for Peace Award of 75,000 dollars and a suitable medal to an individual or group of individuals, of any nationality, in recognition of the most outstanding contribution to the peaceful uses of atomic energy (see *Nature*, October 29, p. 814). The organization set up for making this Award has recently published a brochure giving the background of the whole idea and the general principles to be followed in making the Award. Nominations for the first such Award are invited. The brochure and further information can be obtained from the Executive Secretary, Atoms for Peace Awards, Inc., 77 Massachusetts Avenue, Cambridge 39, Mass.

Auca Indians

THE recent slaying of five missionaries by Auca Indians of eastern Ecuador has aroused concern about the name and nature of these remote South American aborigines. Dr. M. W. Stirling, director of the Smithsonian Institution's Bureau of American Ethnology, states that comparatively little is known about these Indians (*Smithsonian News Release*,

February 25). The term 'Auca' does not refer to any particular tribe but is a Quechua term used in the Andean highlands to refer to any pagan Indian groups as contrasted with those who have been converted to Christianity. The group who did the killing belongs to the Zaparo tribe and lives in the area between the Curare and Napo Rivers. The Franciscans, the Jesuits and the Dominicans established a number of missions among them in the sixteenth, seventeenth, eighteenth and nineteenth centuries. Much of what is known is based on the work of Alfred Simson, an Englishman who spent considerable time with the Zaparos in the 1870's.

White interference has been generally disastrous to the Aucas for several reasons, principally because of factors that upset the normal equilibrium of their lives. Among these were the introduction of the white man's diseases and the unhealthy effect of compelling them to wear clothes in a tropical rain-forest environment. Although the Indians were normally quite nomadic, they were often compelled to work in the fields and perform other tasks unfamiliar to them. Then, too, they resented interference with their own religion and the attempt to substitute for it ideologies completely foreign to their own background and completely incomprehensible to them. They also found objectionable the suppression of many of their own deeply rooted social habits. The white man's ban on polygamy they found especially intolerable. "Because of the hazards of warfare and hunting there were typically more women than men; thus many women found themselves without a normal home and family life, and the men without the prestige of a large family. Inevitably, the Indians revolted against this restriction on their liberties. In the more remote regions where there was virtually no other white population, as among the Zaparos and Jivaros, these revolts were successful and the mortality among missionaries was high."

The Word 'Protoplasm'

Dr. Garrett Hardin, of Santa Barbara College, U.S.A., suggests that careful consideration of the term 'protoplasm' indicates that its various meanings are so contradictory and have such uncertain reference to facts that to call the term meaningless is no more than an act of simple charity (*Sci. Mon.*, 82, No. 3; March 1956). In published statements about protoplasm there are many incompatibilities. In some, protoplasm is a substance; in others, a mixture of substances. Sometimes protoplasm is an entity common to all organisms, while at others 'it' is different in all organisms and even in different tissues of a single organism. Hardin believes that the conceptual framework implicit in the word protoplasm has probably impeded scientific progress. Research workers who are most actively engaged in determining the facts to which protoplasm supposedly refers have the least use for the term.

Leaf Morphogenesis

Studies of morphogenesis in leaves by E. Njoku are concerned with the effect of light intensity on leaf shape in *Ipomoea caerulea* (*New Phytol.*, 55, 1, 91; 1956). In this paper the author has made a useful contribution to our knowledge of heteroblastic development. Observations are recorded of the changes in leaf shape from node to node in plants of *Ipomoea caerulea* grown under varying intensities of light. These show that the amount of leaf lobing decreases with decreasing light intensity, and lobing is completely suppressed in 0·23 daylight and lower intensities. Plants already producing lobed leaves in full daylight revert to the production of entire leaves when transferred to deep shade, and shade plants producing entire leaves soon begin to produce lobed leaves on transfer to full daylight. There is no correlation between the changes in leaf shape and changes in leaf area, cell size and cell number. The shape of the leaf is determined early in ontogeny and is not appreciably altered during the later growth of the leaf. The effect of light intensity on leaf shape is compared with the effect of length of day reported by Ashby (1950). Length of day has no effect on leaf shape during the vegetative phase of development; but by accelerating or retarding flowering at the apex, length of day exerts a small effect on leaf shape; the leaves just below the terminal inflorescence are usually simpler in shape. The experimental results are discussed with reference to current views on the factors controlling heteroblastic development, and it is concluded that more work is required before the effect of light intensity on leaf shape can be definitely referred to factors as specific as carbohydrate nutrition or auxin supply.

Society of Instrument Technology, Ltd.

The Society of Instrument Technology, Ltd., has been functioning until recently by the efforts of its honorary officers, and for some time the need has been felt for a full-time staff and permanent headquarters in London. The Society's membership, in all classes, is nearly fourteen hundred, and with the increasing recognition of the need for automation in industry, its activities are growing day by day. An office has now been taken at 20 Queen Anne Street, London, W.1, the headquarters of the Scientific Instrument Manufacturers' Association of Great Britain, Ltd., and a full-time secretary and clerical staff engaged. The secretary is Commander A. A. W. Pollard, who recently left the Royal Navy after more than thirty-one years of service in the Executive Branch. Dr. Harold Moore will continue for the time being as honorary editor of the Society's *Transactions*. All correspondence should be sent to the above address.

Society of Biological Chemists, India

The Society of Biological Chemists, India, was founded in 1930 and has recently celebrated the first quarter-century of its existence by publishing a "Silver Jubilee Souvenir" (pp. 262; from the Society, Bangalore, 1955). This consists of about fifty short papers contributed by biochemists from many different countries, and the list of authors contains many distinguished names. Some of the papers are descriptions of original work; others are short summaries and discussions of recent discoveries in particular fields of biochemical research. The Society publishes an *Annual Review of Biochemical and Allied Research in India*, and *Proceedings* which summarize the papers read at its ordinary meetings and at its annual symposia. By means of these publications and meetings, the Society helps to co-ordinate the activities of workers in biochemistry in the different parts of India.

Helminthological Society of India

At the annual general meeting of the Helminthological Society of India, held in Agra on January 3, the following officers were elected: *President*, Prof.

M. B. Mirza (Aligarh); *Vice-Presidents*, Dr. G. S. Thapar (Lucknow) and Dr. H. D. Srivastava (Izatnagar); *Chief Editor*, Dr. G. S. Thapar (Lucknow); *Honorary Secretary and Treasurer*, Dr. B. S. Chauhan (Zoological Survey of India, 34 Chittaranjan Avenue, Calcutta 12); *Foreign Secretary*, Miss N. G. Sproston (Mandapam, Camp); and *Business Manager*, Dr. Kr. S. Singh (Lucknow). At the meeting it was decided to draw up a scheme for a National Parasitological Laboratory in India, and a committee of four was appointed with Dr. Thapar as president and Dr. Chauhan as secretary.

University of London

THE following appointments in the University of London have been announced: Prof. E. M. Glaser, professor of physiology in the University of Malaya, to the University readership in physiology tenable at the London Hospital Medical College; Dr. B. C. L. Weedon, lecturer in organic chemistry at the Imperial College of Science and Technology, to the University readership in organic chemistry tenable at that College. The title of professor of genetics in the University of London has been conferred on Dr. Hans Grüneberg, in respect of his post at University College.

The Night Sky in May

NEW moon occurs on May 10d. 13h. 04m., U.T., and full moon on May 24d. 15h. 26m. The following conjunctions with the Moon take place: May 3d. 04h., Mars 7° S.; May 11d. 20h., Mercury 2° N.; May 13d. 13h., Venus 6° N.; May 17d. 03h., Jupiter 7° N.; May 24d. 09h., Saturn 3° N. Mercury sets at 21h. 30m. and 21h. 05m. on May 1 and 15, respectively, but after this draws too close to the Sun for favourable observation; its stellar magnitude is 0·3 and 2 at the beginning and middle of the month, respectively, the decrease in brightness being due to the decrease in the visible portion of the illuminated disk from 0·450 to 0·098. Venus sets at 23h. 45m., 23h. 30m. and 22h. 35m. on May 1, 15 and 31, respectively. Its stellar magnitude remains almost −4·2 throughout the month, although the visible portion of its illuminated disk decreases from 0·400 to 0·140; this constant magnitude is due to the fact that its distance from the Earth decreases from 98 to 77 million miles, the decreasing distance almost balancing the decreased portion of the illuminated disk. Mars rises in the early morning hours, at 2h., 1h. 30m. and 0h. 50m. at the beginning, middle and end of the month, respectively; it is close to θ Capricorni on May 3, and its eastward motion is easily noticed by comparing its positions with this star over a few nights. Jupiter, visible throughout the night, sets in the early morning hours, at 2h. 20m., 1h. 30m. and 0h. 30m. on May 1, 15 and 31, respectively, and is conspicuous in the constellation Leo. Saturn rises at 21h., 20h. and 18h. 45m. at the beginning, middle and end of the month, respectively, setting in the early morning hours; it lies rather low in the constellation Scorpius but is easily recognized, its stellar magnitude remaining 0·3 throughout the month. No occultations of stars brighter than magnitude 6 occur in May. The η-Aquarid meteors are active in the first week of the month. There will be a partial eclipse of the Moon on May 24, invisible at Greenwich but visible in Australasia; the end will be visible in South Africa. The Moon enters the umbra at 13h. 48·7m. and leaves it at 17h. 13·8m.

Announcements

THE Twentieth International Physiological Congress, organized by the Belgian Society of Physiology under the auspices of the International Union of Physiological Sciences, will be held in Brussels during July 30–August 4. An international meeting of pharmacology will be held during the Congress. Further information can be obtained from the secretary of the Congress, Prof. J. J. Reuse, Faculté de Médecine, 115 Boulevard de Waterloo, Brussels.

THE eighth of the annual symposia on "Phytopharmacie et de Phytiatrie" will be held in the State Agricultural Institute, Ghent, during May 7–8. Further information can be obtained from the Secretary of the Symposium at the Rijkslandbouwhogeschool, Coupure Links 233, Ghent.

THE laboratories and technological sheds of the British Rayon Research Association, Heald Green Laboratories, Wythenshawe, Manchester 22, will be open to visitors on May 10 and 11. There will also be a special open day for textile teachers on July 6, when Mr. L. Gibson and Dr. A. S. Roberts will speak on "Direct Spinning on the Stains Machine", and Dr. J. Mann on "Recent Researches on the Fine Structure of Cellulose".

THE Institute of Personnel Management and the National Institute of Industrial Psychology are jointly arranging a five-day course on "The Use of Statistics in Personnel Management", to be held during May 14–18 in the latter body's headquarters at 14 Welbeck Street, London, W.1. The course is designed for personnel officers and others with no previous training in the use of statistical methods and their application to personnel administration. The fee for the course is ten guineas. Registration forms and further information can be obtained from the Courses Secretary, Institute of Personnel Management, Management House, 8 Hill Street, London, W.1.

THE Bourke Lectures of the Faraday Society for 1956 will be given by Prof. J. J. Hermans, of the Laboratory of Inorganic and Physical Chemistry, University of Leyden, as follows: May 1, the physical properties of polymer solutions (at 5.15 p.m. in the Physical Chemistry Lecture Theatre, Imperial College of Science and Technology, London); May 3, polyelectrolytes (at 4.30 p.m. in the Chemistry Department, University of Birmingham); May 4, light scattering by solutions (at 5 p.m. in the Nicholson Lecture Theatre, University of Liverpool). The lectures will be open to the public, without ticket. Further information can be obtained from the Faraday Society, 6 Gray's Inn Square, London, W.C.1.

THE firm of Shell Austria, A.G., has established two scholarships, each worth about £70 a year, for the study of chemistry or some allied technical subject for six years at an Austrian university. Two more scholarships will be awarded each year so that, from 1960 onwards, there will always be twelve such Shell students. The selection of candidates will be made by Shell in close collaboration with the Austrian Ministry of Education.

ERRATUM. In the communication entitled "Influence of a Magnetic Field on Thermal Convection Patterns", by W. C. Levengood, in *Nature* of March 31, p. 631, the lower part of Fig. 2 has been reversed.

EDUCATION GROUP OF THE INSTITUTE OF PHYSICS

ANNUAL CONFERENCE

At the annual conference of the Education Group of the Institute of Physics, held in London during April 5–6, the topic on the first day was the teaching of atomic and nuclear physics. On the succeeding day the conference discussed the adequacy of the Advanced Level examinations of the General Certificate of Education as criteria for university selection.

Opening the first session, Prof. P. B. Moon and Prof. W. E. Burcham (University of Birmingham), in a joint paper read by the latter, described the modern physics content of their honours physics courses at Birmingham. At school, the student would have acquired some awareness of the applications of nuclear physics and would use the concepts of atom and electron in chemistry, but with no detailed knowledge of quantum theory. The university course aims at showing the development of modern physics from the basis of classical physics, withholding the more difficult concepts until the student is mature enough to grasp them—quantum mechanics, for example, belonging to the post-graduate courses. The inter-relation of physics with other studies, such as chemistry and engineering, means that the courses must be planned in co-operation with other faculties; and the inter-relations between various parts of physics can provide analogies to introduce modern concepts, since the main difference between atomic physics and ordinary classical physics is simply one of scale. The first year of the honours physics course at Birmingham is a consolidation of school work, without any particular emphasis on physics itself.

The second-year course includes ionization, radioactivity and spectroscopy as an introduction to the Bohr-orbit atom. Descriptive lectures on nuclear physics are given in the third year, with some advanced lectures on special topics such as luminescence and high-energy machines; and some of the practical work at this stage is done as an assistant to a research team. A good deal of formal instruction is given in the postgraduate courses, during which time the student's capacity for original thinking is developed.

Mr. A. L. Chick (Associated Electrical Industries, Ltd., Aldermaston) spoke of the training of the research worker as an individual, and the creation of a research team as a unit. The modern research laboratory is also a teaching institution, and the lecture courses at Aldermaston include mathematics, electronics, vacuum work, and nuclear physics. Mr. Chick described how a research group convened to design and operate a small research reactor was trained on a project of almost comparable scale, the erection of a Van de Graaff generator and its use on a programme of fundamental research on the spin and parity of nuclear energy levels. While valuable results were obtained incidentally, the real aim was to train the team in the techniques they will apply to the reactor.

The chairman of the Education Group, Dr. J. Topping (principal of Acton Technical College), gave, with his colleague, Dr. J. W. Warren, an outline of the part-time day-release courses at Acton. Among special topics in the syllabus are instrumentation, heat transfer, the use of boiling liquid metal coolants, the properties of materials at high pressures and temperatures, the effects of radiation on materials, the processing of active material, and health physics. Practice in numerical computation and some experimental work are also included. The whole outlook of the course is practical, differing entirely from that given at a university where the ambient atmosphere is one of preoccupation with fundamental research. Indeed, as Dr. Warren added, the only theory really needed is the mass–energy relationship.

The next speaker, Mr. W. O. Peacocke (St. John's School, Leatherhead), then described the work he has been doing with sixth-form boys, using apparatus very largely made by the boys themselves. Given a Geiger counter, a scaling unit and suitable radioactive sources, several good demonstrations to illustrate the historical development of nuclear physics can be presented. The dozen or more class experiments, as performed by boys using microcurie quantities for safety reasons, were impressive in the extreme. Mr. Peacocke, like Joule and Tyndall, is able to relax even amid the rigours of an Alpine holiday and enjoy a little physics; and, having taken his nuclear emulsion plates to a mountain-top, he gave his pupils an excellent project of plate-searching and mosaic-building which produced fine photographs of cosmic ray events. Enterprise of this kind, while enriching the experience of a few fortunate pupils, has a far wider effect in opening the eyes of other teachers to the possibilities available.

Dr. J. M. A. Lenihan (Western Regional Hospital Board, Glasgow) gave his personal impressions of the Geneva Conference on the Peaceful Uses of Atomic Energy. He felt that the participating countries had really laid down their cards, and seemed in fact to have been following almost the same lines independently. In the United States, a long-term programme to discover the most efficient type of reactor is being planned; the U.S.S.R., some way behind, seems urged rather by the propaganda value of the achievement than the actual need for power. Great Britain, he said, urgently needs power to supplement coal resources and is committed to a rather unsophisticated type of reactor to yield results reasonably soon.

The discussion on the adequacy of the Advanced Level examinations of the General Certificate of Education as a guide to university selection was opened by Miss K. E. Parks (North London Collegiate School) and Mr. J. A. Ratcliffe (Cavendish Laboratory, Cambridge). Remarking that the examination was never intended as a university entrance test, Miss Parks suggested that both the syllabus and the number of questions to be answered should be reduced. General fitness for further education might be tested separately, say by means of an essay; and a clearing-house system like that of the teacher-training colleges might simplify matters. Final selection for entry into a special honours course might well be postponed until the end of the first university year; and, whether or not future promise can be assessed beforehand, the actual progress made

by a student when he is there depends on the effectiveness of the tutorial guidance at the university. Mr. Ratcliffe also expressed a preference for a shorter syllabus, and a more intelligently searching kind of question. From the point of view of the university, which aims at training people to think, he felt it unfortunate that so many students go up having done physics at school; for they arrive completely misunderstanding the fundamentals, complacently superior towards the important simple things, and loving mathematical proofs for their own sake. After naming specific topics which he would like to see omitted from the Advanced Level syllabus, he said that he regards electricity as the most satisfying part of the work, since it compels a logical treatment; and he noted with interest the Science Masters' Association report on "The Teaching of Electricity", with its logical treatment quite different from the usual historical approach.

During the discussion, Dr. H. R. Lang (secretary of the Institute of Physics) said that physics could certainly be started at the university, and the new transfer scholarship scheme of Imperial Chemical Industries, Ltd. (see *Nature* of March 31, p. 606) would soon be promoting this. This scheme, incidentally, may miss some of the best boys, since those who have never done science at school might be unaware of the satisfactions it offers.

At the final session of the conference a short paper on sandwich diploma courses, by Prof. M. R. Gavin (University College of North Wales, Bangor), explained the aims and organization of the four-year courses that he had inaugurated at Birmingham, the standards expected, and the award to be given at the end. This was followed by some figures on specialization in the sixth forms of grammar schools, collected by Dr. N. Thompson (University of Bristol). He felt that the proportion of the time allotted to specialist subjects was excessive; but schoolmasters in the discussion were divided on the point, since the really relevant matter is the way the remaining time is used.

G. R. Noakes

ENRICO FERMI AND HIS CONTRIBUTIONS TO PHYSICS

HALF of an issue of the *Reviews of Modern Physics* (27, No. 3, 249; 1955) is dedicated to the memory of the late Prof. Enrico Fermi, one-time president of the American Physical Society, who died on November 29, 1954, and consists of the proceedings of the memorial symposium held at the Washington meeting of the Society on April 29, 1955, over which Prof. H. A. Bethe presided. It contains addresses by F. Seitz, E. J. Konopinski, E. Segré, W. H. Zinn and H. L. Anderson, together with photographs of sample pages from Prof. Fermi's numerous notebooks which are now being preserved in the Harper Memorial Library of the University of Chicago. The speakers were introduced individually by Prof. Bethe, who referred, in his opening remarks, to Fermi as "unique among the great physicists of the twentieth century in being one of the greatest in experimental physics and at the same time being one of the greatest theoretical physicists. He was unique also in the width of contributions. He may have been one of the last physicists who knew almost all of physics and used it in his research".

Prof. Seitz spoke about Fermi statistics and its applications, and Prof. Konopinski about Fermi's theory of beta-decay, and these two lectures illustrate how two small theoretical articles originally contributed by Fermi to the *Zeitschrift für Physik* in 1928 and 1934, respectively, came to have such tremendous influence on the progress of physics in recent years. Profs. Segré, Zinn and Anderson deal with different aspects of Fermi's experimental work during the past twenty years. Prof. Segré gives an interesting description, including many personal reminiscences, of the work on neutrons performed by Fermi and his school in Rome during 1934–35 and for which Fermi was awarded a Nobel Prize in 1938. Early in 1939, just about the time when the news of uranium fission reached America, Fermi arrived in the United States and became engaged on the work—atomic energy—which was to occupy his attention for the rest of his life. Prof. Zinn, in describing the part played by Fermi in the atomic energy project, considers three separate periods: the first, January 1939 to May 1942, when Fermi's work was centred on Columbia University; the second, May 1942 to the winter of 1943–44, when Fermi's work was mainly directed towards bringing about the self-sustaining chain reaction and the construction and operation of the production piles at the Hanford Engineering Works of the Manhattan District; and the third, after May 1944, when Fermi transferred to the Los Alamos Laboratory in New Mexico and finally to Chicago.

In Chicago Prof. Anderson was actively associated with Fermi and was engaged on scattering experiments using intense beams of mesons obtained from a large synchrocyclotron. Prof. Anderson describes in his talk the close personal interest, even to the actual construction with his own hands of several pieces of apparatus and the observation of various instruments, that Fermi took in the experiments. The object of the investigation was to uncover the part that π-mesons play in the nuclear interaction: and though Fermi did not live long enough to see all his predictions verified, his clear understanding of this, in addition to many other similar problems, pointed the way to the present knowledge of the pseudoscalar nature, strong coupling, short-range interaction, charge independence and causal behaviour of π-mesons.

THE BOSE INSTITUTE, CALCUTTA

THE thirty-eighth anniversary meeting of the foundation of the Bose Institute was celebrated on November 30, when (the late) Dr. Sunder Lal Hora delivered the seventeenth Acharya Jagadish Chandra Memorial Lecture. He chose as his subject "Conflict versus Co-operation as Factors in Evolution".

The director, Dr. D. M. Bose, in his report reviewed the activities of the Bose Institute for the past year. He said that the Institute had submitted to the Central Government plans and estimates for expansion of activities during the second five years. All the plans for expansion of the research activities of the Institute depended on the provision of additional buildings for laboratory accommodation. For this purpose additional land for building purposes is necessary, as there is very little land available in the present location of the Institute. He pointed out that to the west of the Institute the Corporation of

Calcutta has a plot of land lying vacant at present, which he hoped the Corporation may give on lease to the Bose Institute.

The Institute is developing the recently acquired area at Shamnagar as an experiment farm. A donation of Rs. 40,000 from the Government of West Bengal is being utilized for the erection of a laboratory. It is proposed to concentrate at Shamnagar most of the investigations on the effects of different kinds of radiation in producing mutation in plants. So far, only the mutants of economic plants possessing improved economic properties compared to their parents have been isolated and propagated. It is now proposed to devote more attention to the Mendelian characters of the mutant produced. The sources of radiation employed up to now have been X-rays and β-rays from radioactive phosphorus and sulphur. Recently, Dr. K. T. Jacob, head of the Department of Botany, has returned from a scientific tour extending from Sweden to the United States, visiting many of the important plant-breeding stations, where the effects of irradiation on plants growing in fields are studied. The method generally employed is to use a powerful source of gamma-radiations from cobalt-60. The radioactive cobalt, which is produced rather cheaply in atomic reactors, is used in strengths varying from 100 to 200 curies and more. Special techniques for handling such unusually powerful sources are necessary. Experimental plots of size of about 10–15 acres of land are required for field experiments. Dr. Bose expressed the hope that with the co-operation of the Department of Agriculture, West Bengal, it may be possible to undertake such large-scale investigations. This field irradiation method is now recognized as one of the most promising methods of improving crops of economic plants. Besides producing rust-resistant wheat, radiation from cobalt-60 is being employed as an alternative method in storing potatoes. The sprouting of potatoes can be partially to completely inhibited by exposing them to gamma-radiation of total strength varying from 5,000 to 20,000 r. This method of potato storage may ultimately replace the more expensive cold storage method now in use.

Reference was also made to the international co-operative work to be undertaken for the International Geophysical Year 1957–58, in connexion with which the Bose Institute proposes to make continuous records of intensities of different components of the cosmic rays with apparatus installed in the Mayapuri Research Station, Darjeeling.

Dr. Bose also pointed out that in 1958 will occur the hundredth anniversary of the birth of Sir J. C. Bose, the founder of the Institute; he hoped his fellow-countrymen will celebrate the centenary in a befitting manner. He disclosed that on request from the Ministry of Education, the Government of India, he has sent a script on the life and activities of Sir J. C. Bose for the preparation of a documentary film.

RELATIVITY AND SPACE TRAVEL

IT has long been evident that the special theory of relativity is very imperfectly understood, even by mathematical physicists of high distinction. More than fifteen years ago, in two articles in *Nature*[1], I directed attention to one type of mistake, and the abundant correspondence that followed, though it showed that some clarification had been achieved, was on the whole disappointing because of the depth and variety of the misconceptions that it revealed. However, no further action then seemed possible, and the only thing to do was to wait for some major error to occur which would force physicists to re-examine their assumptions.

A new factor, however, has now entered the situation. Space travel at high velocity is being regarded as a serious possibility in the not enormously distant future. Sir George Thomson, for example, in his recent fascinating book, "The Foreseeable Future", p. 89 (Cambridge, 1955), discusses a journey to the nearest star and back in just over seventeen years by terrestrial clocks. He states, however, that owing to "the relativistic contraction of time", the travellers would have "aged" by only 14½ years, and adds the following footnote: "The bearing of the relativistic contraction of time on this problem has been questioned, since it leads to an apparent paradox, but the best opinion is that the contraction would occur and that the returning astronaut would, in fact, find that time had gone more rapidly on the earth than on his space ship".

There could be no stronger confirmation of the misunderstanding to which I have referred than the fact that, fifty years after Einstein's clear and logical paper[2], this can be called a matter of "opinion". It is still more serious that the "best" opinion can be regarded as that which is simply a direct denial of the principle of relativity, but of that hereafter. The point to notice at the moment is that the question is no longer an academic one; it has become a matter of profound social and philosophical importance, no matter whether space travel is imminent or not. It needs little imagination to see that if the public is led to believe that there is scientific sanction for the idea that it is *possible* to postpone the date of one's death by space travel, some very undesirable consequences might ensue. It is therefore necessary to bring the matter forward again, so that there shall no longer be differences of opinion on a matter of straightforward logic.

The calculation by which Sir George Thomson arrives at the figures quoted above is based on a formula given by Prof. W. H. McCrea[3] in a discussion of the famous 'clock paradox'. Two observers, M and R, separate and then re-unite at uniform linear velocity. The clock of the moving one will run slow, and so will be behind on reunion. But since either can be supposed to have moved, M's clock will be behind R's and R's behind M's, which is impossible. McCrea purports to show that, in fact, on reunion M's clock will be behind R's by an amount $2T(1 - \alpha)$, where T is the time of the one-way journey at uniform velocity V, and $\alpha = (1 - V^2/c^2)^{1/2}$, c being the velocity of light.

One possible difficulty can be removed at the outset. McCrea is not concerned with the brief accelerations which must occur at the beginning,

middle and end of the journey. Since T is independent of them, it is supposed so great that their effects, if any, are by comparison negligible. The retardation given above, calculated by the formulæ of special relativity alone, is therefore at least a close approximation to the supposed truth.

It is not necessary (though it is not difficult) to analyse McCrea's calculation in order to see that his result must be wrong. It would, in fact, be misleading to do so, for it would suggest that he had made a mathematical error, whereas the error is in the pre-mathematical ideas. The fundamental principle of relativity, in its application to the case of two bodies in uniform relative motion, is simply that the motion is a relation between them and not something belonging to one or the other, so that all its effects, if any, must apply equally to both. If, then, the two clocks in question, which would have continued to agree if they had not separated, show different times on reunion, something must have happened to one which did not happen to the other, and nothing is in question except their relative motion. Hence they cannot show different times on reunion.

But those familiar with the customary phraseology of the theory will ask what is meant by the familiar statement that a moving clock runs slow. How can that be, they will ask, if the clock can equally well be said to be at rest (and so running normally) or moving (and so running slow)? It simply means that its reading is behind that of an imaginary stationary clock at the same place, which is synchronized with the observer's stationary clock. The synchronization of the two 'stationary' clocks is the determining factor; nothing at all happens to the moving clock.

The revolutionary fact that Einstein pointed out in 1905 was that we have no intuitive means of assuring ourselves that two similar clocks at different places are synchronized—or, in other words, that two events happening at different places are simultaneous. Hence we must give up the idea that simultaneity of separated events is a phrase needing no explanation, and choose *by definition* what it shall mean. To be of practical use, the definition must be in terms of some physical process actually performable. We can imagine several such processes; but they all involve some assumption about the passage of light unless we include that passage in the definition.

Einstein therefore defined synchronism as follows. R (stationary) regards a clock at X as synchronized with his own when, if he sends a beam of light to that clock and receives it back, the time shown by the clock at X is half-way between the times, by his clock, of emission and return of the light. But this requires that M (moving towards X) will get a different result from the same process. Suppose M, at the time of R's emitting the light, is adjacent to R with his clock agreeing with R's. Then obviously M will receive the returning light earlier than R, and the time which it shows the clock at X to indicate will *not* be half-way between emission and return of the light by M's clock. Hence the clock at X will not be synchronized with M's. We cannot say that, because R is at rest and M moving, R is right and M wrong, for M might equally well retort that it is R who is moving. Hence our definition of synchronism, or of simultaneity, demands that two observers in relative motion will have different ideas of what events, occurring at different places, are simultaneous with one another.

We can now see what happens when our space traveller sets off. Nothing happens to his clock; but to compare it with a terrestrial one you must read them at the same time, otherwise you can get any result you like. The terrestrial observer, choosing what he calls the same moment, finds that the traveller's clock is slow. The traveller, however, says that the terrestrial observer has compared them at different moments; he makes the 'right' choice and finds the terrestrial clock to be slow. Both are right—which would be impossible if the effect were something that happened to a clock instead of to a judgment of simultaneity. When the observers meet again they are both at the same place and relatively at rest. Their judgments of simultaneity agree, and so their clocks agree. All this applies also to heartbeats. The observers will have 'lived' the same time and made the same progress towards the tomb.

What I have written here is simply a paraphrase of Einstein's original paper on the subject. After all allowance has been made for the mental effort required to discard deeply rooted prejudices, it is impossible after fifty years to justify the wholesale abandonment of even elementary reasoning which physicists have allowed themselves to sanction. This outstanding triumph of reason over prejudice has been distorted into a triumph of magic over reason, and the state of mind thus engendered exposes us to dangers which it is impossible to exaggerate. I first directed attention to it nearly thirty years ago and have done so at intervals since[4]; yet the mistaken interpretation of the FitzGerald contraction and clock retardation persists. It is necessary to give a few examples.

Prof. P. S. Epstein[5] makes a relayed appeal to authority, a device that became unscientific at the close of the Middle Ages. Dr. R. A. Millikan had told him that H. A. Lorentz had said that the FitzGerald contraction was "no less real than . . . the variations that are produced by changes of temperature". The meaning of this depends, of course, on what one means by "real", but, whatever that may be, the quotation is irrelevant since it misses the essential fact that if one of two equal rods is cooled, that one unambiguously contracts, whereas if one is moved, you can equally well say that it or the other has "contracted". Prof. L. Infeld[6] tries to save the situation by claiming that a journey covering an exact number of hours will show that a moving clock has slowed down; but if the minute hand has to be read also the whole test becomes meaningless. He adds, however, that the matter cannot be fully elucidated without reference to the social attitude which the physicist takes. Prof. McCrea[7] has to say that his observer M sees that R, after reaching a distance αX, " 'cheats' by rushing out to distance X and back again to distance αX in negligible time". Cheating indeed! In Sir George Thomson's example light would take a little more than a year to cover the distance which M sees R cover in negligible time.

I know of no other example in the history of science in which such fantastic propositions have been put forward as sober scientific truth. The theory of relativity is unique, not merely in its difficulty, which is solely one of discarding prejudices and is excusable, but in its paralysing effect upon the reason, which is not excusable. It looks as though the reaction from excessive rationalism that marked the beginning of the modern scientific era has gone too far, and that a course in traditional logic should be included in the training of all science students. Physicists should

not have been misled by such words as 'contraction' and 'retardation' into supposing that the objects said to experience these effects suffer changes analogous to those produced by lowering temperature or by lengthening a pendulum. Sooner or later the lesson will have to be learnt. Let us hope that it will be before some patriarch embarks on a trip to the Andromeda nebula in an attempt to outlive his great-granddaughter.

One other point must unfortunately be mentioned, as it will undoubtedly be raised if this article has the desired effect of making readers turn to Einstein's paper. That paper contains a most regrettable error, in a statement that a clock moving in a closed curve will be found, on returning to its starting point, to be behind a stationary clock. That this is an error there is no question, for such a motion is continuously accelerated and with such motions the special theory of relativity is powerless to deal. But in fact the result given did not follow even from the special theory. At that stage, when Einstein was introducing a fundamental modification of physical theory, he did not concern himself with details of mathematical rigour, which could be left for later investigation, and he wrote: "We assume that this definition of synchronism is free from contradictions, and possible for any number of points; and that . . . If the clock at A synchronizes with the clock at B and also with the clock at C, the clocks at B and C also synchronize with each other". We know now that this assumption is only partially valid; two Lorentz transformations in different directions do not commute. Consequently, the theory cannot be applied to motion in a polygon and then extended to a closed curve. This incidental passage in Einstein's paper has therefore no relevance to the present problem.

HERBERT DINGLE

[1] *Nature*, **144**, 888 (1939); **146**, 391 (1940).
[2] *Ann. der Phys.*, **17**, 891 (1905). English translation in "The Principle of Relativity", by A. Einstein and Others (Methuen, 1923).
[3] *Nature*, **167**, 680 (1951).
[4] For example, *Nature*, **122**, 673 (1928); **133**, 818 (1934); **139**, 784 (1937); *Mon. Not. Roy. Astro. Soc.*, **113**, 393 (1953).
[5] *Amer. J. Phys.*, **10**, 207 (1942).
[6] *Amer. J. Phys.*, **11**, 219 (1943).
[7] *loc. cit.*

PROF. DINGLE's exposition of relativity theory is wrong and a plain reply is needed.

Consider the example given by Sir George Thomson and quoted by Dingle. For definiteness, suppose Thomson's traveller starts from rest on the Earth, visits the nearest star and comes to rest on it, then returns so as to come to rest again on the Earth. The traveller needs some form of engine in order to gain speed at the start of his journey, to stop himself at the star, to gain speed for his return journey and, finally, to stop himself at the Earth. Over most of his journey, his engine may be cut out. His path, while his engine is cut out, we shall call a free path. His career from any time before his departure to any time after his return consists essentially of four free paths: a free path with the Earth until he leaves it, a free path most of the way to the star, a free path most of the way back, and again a free path with the Earth after returning to it. These do not add up to a single free path: no matter how long the man waits on the Earth without switching on his engine, he will not find himself on the way to the star, nor, without again using his engine, will he ever find himself on his way back again. Nevertheless, the duration of the journey does not depend essentially upon the duration of the parts when the engine is in use. The same uses of the engine would equally well enable the man to visit the star were it, say, a million times farther away.

On the other hand, the career of a second observer who remains on the Earth is a single free path.

This distinction between the two observers is an *absolute* distinction. That it is so is shown by the simple fact that one of the men has to use an engine and the other not. This common-sense distinction cannot, of course, be removed by any 'principle of relativity'. Even if the traveller chooses to regard himself as at rest and the Earth as departing and returning, it is still he and not the man on the Earth who has to use the engine. Therefore, no mere appeal to a principle of relativity enables us to say whether or not the two men agree as to the duration of the journey.

In particular, there is no relevance in saying, as Dingle does, that nothing has happened to the traveller's clock and so it must show the same time as the clock on the Earth. The question is not, What has 'happened' to the clocks? It is, What have the clocks measured? Dingle's statement that the clocks must agree has no more validity than a statement that the milometers of two cars that take different routes to the same place should agree as to the distances travelled.

The answer given by the theory of relativity is very simple. For what we have been calling a free path corresponds in relativity theory to a segment of a geodesic world-line. The world-line of the observer on the Earth is a geodesic; the world-line of the traveller is not a geodesic (though it can be made up of parts of four different geodesics). In the case of this kind of geodesic, the geodesic interval between two events is the longest interval between them (not the shortest as in some other cases). The interval or proper-time, in accordance with the theory of relativity, is what is measured by a clock having the same world-line. Therefore, the clock on the Earth records a longer time than the clock carried by the traveller. This is the result given by Thomson and is a strictly correct inference from relativity theory. (The above argument is sufficient for the simple case considered. In other cases, the geodesic need not give the longest interval except in comparison with neighbouring world-lines between the same two events, and the geodesic need not be unique.)

Regarded geometrically, Dingle's assertion that the clocks must agree is equivalent to saying that the interval between two events or the distance between two points in four dimensions is the same along every path joining the events or points. His assertion would require relativity theory, in the accepted sense, to be rejected and the universal time of classical theory to be reinstated. It is, in fact, evident that Dingle still believes such a time to exist. Otherwise his contention that "you must read them [the clocks] at the same time" is meaningless.

Dingle's "paraphrase" of Einstein's paper is a travesty. He purports to explain special relativity without once mentioning the all-important postulate of the existence of inertial frames of reference. So far as what Dingle is trying to explain is concerned, Einstein was considering only observers at rest in inertial frames. For present purposes, these are equivalent to observers whose world-lines are geodesics.

In my example of the clock paradox, observer R remains at rest in an inertial frame, that is, he remains in a free path; observer M transfers from one inertial frame to another, that is, he transfers from one free path to another and these different free paths do not combine into a single free path. Once again, this is an absolute distinction between R and M.

My purpose was to point out how this absolute distinction results in a distinction between the ways in which R and M describe the relative journey. Therefore, the usual relativistic result cannot, in fact, be made to yield a paradox. My purpose was not to re-establish the usual result. Had it been, I need only have remarked that two curves with the same end-points in general possess different lengths. But it is this obvious result that Dingle now denies.

In spite of what Dingle writes, physicists and mathematicians are quite certain about what follows rationally from the postulates of relativity theory. What no one can be certain about in the same way is the extent to which the actual universe conforms to the postulates. By reason of the many tests of the theory, most of us are convinced that the theory can be correctly applied to the phenomena here considered. However, Dingle might be entitled to question this applicability. What he is not entitled to state is that someone else's calculations "must be wrong" for unspecified reasons.

W. M. McCrea

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Prof. McCrea wanders widely from the point, and I do not propose to follow him. Of course, the traveller must be accelerated in order to start, turn and stop again, and this may infinitesimally affect his clock. As McCrea agrees, the accelerations may be extremely brief, so the clock cannot lose much time in them or it would go backwards. The $2\frac{1}{2}$ years in question is a function of T, the time of what he now calls "the free path", during which the engine is cut out. Hence the "absolute" distinction, arising from the use of the engine, is eliminated. McCrea makes no comment on the remarkable feat of R in beating light to a standstill. His remarks about geodesics are a wide and needless generalization of the problem; he has said nothing in answer to the definite statements I made.

One or two minor points in his letter require brief comment. First, he says, "The question is not, What has 'happened' to the clocks? It is, What have the clocks measured?" The question is simply, Will one clock differ from the other or not? That is all. What they have measured, if anything, is a metaphysical question; it does not enter the problem.

Secondly, McCrea says that I must believe in the classical universal time because I say "you must read them [the clocks] at the same time". My article stated specifically that "the same time" for one observer was not "the same time" for another, so how can this imply belief in the classical universal time?

Thirdly, McCrea calls my paraphrase of Einstein's paper "a travesty" because I have not mentioned "the all-important postulate of the existence of inertial frames of reference". I have looked through Einstein's paper again, and find that he also fails to mention this all-important postulate: he speaks only of "stationary" and "moving" systems, as I did. This may make his paper a travesty of reason, though I do not think so; but I cannot accept it as a criticism of my paraphrase.

Fourthly (and this, of course, is the really serious aspect of the matter), McCrea says, "physicists and mathematicians are quite certain about what follows rationally from the postulates of relativity theory". How, then, does he explain the number of different solutions of the clock paradox, a few of which he mentioned in his first letter, and how is it that it has been left for him to be the first to discover, after forty-six years, that there is no paradox at all?

Finally, he says that I am not entitled to state "that someone else's calculations 'must be wrong' for unspecified reasons". I claim that my article did specify the reasons.

Herbert Dingle

PERFLUOROALKOXY RADICALS

By D. A. BARR, W. C. FRANCIS and Dr. R. N. HASZELDINE

University Chemical Laboratory, Cambridge

It is reasonably well established[1] that primary alkoxy radicals react either (*a*) by hydrogen abstraction from a molecule QH:

$$R\mathrm{CH_2}.\mathrm{O}\cdot + QH \longrightarrow R\mathrm{CH_2OH} + Q\cdot$$

for example,

$$R\mathrm{CH_2O}\cdot + R\mathrm{CH_2O}\cdot \longrightarrow R\mathrm{CH_2OH} + R\mathrm{CHO}$$

or (*b*) by loss of formaldehyde to give a radical of shorter chain-length:

$$R\mathrm{CH_2}.\mathrm{O}\cdot \longrightarrow R\cdot + \mathrm{HCHO}$$

It is now clear that perfluoroalkoxy radicals $R\mathrm{CF_2}.\mathrm{CF_2}.\mathrm{O}\cdot$ behave somewhat similarly. Such radicals can abstract hydrogen in a manner analogous to that in (*a*) above; in absence of compounds containing hydrogen, however, a disproportionation reaction, for example,

$$R\mathrm{CF_2}.\mathrm{CF_2}.\mathrm{O}\cdot + R\mathrm{CF_2}.\mathrm{CF_2}.\mathrm{O}\cdot \longrightarrow R\mathrm{CF_2}.\mathrm{CF_2}.\mathrm{O}.\mathrm{F} + R\mathrm{CF_2}.\mathrm{COF}$$

is not observed, and is indeed unlikely, since it would require fission of a C—F bond. On the other hand, loss of carbonyl fluoride, the fluorine analogue of formaldehyde, from such radicals:

$$R\mathrm{CF_2}.\mathrm{CF_2}.\mathrm{O}\cdot \longrightarrow R\mathrm{CF_2}\cdot + \mathrm{COF_2}$$

appears to be a general reaction in fluorocarbon chemistry, and is illustrated by the following three examples.

(1) Photochemical oxidation of a perfluoroiodoalkane such as $\mathrm{C_2F_7I}$ is extremely rapid and yields only carbonyl fluoride and (by attack on the glass reaction vessel) silicon tetrafluoride[2]. Facile breakdown of a perfluoroalkyl group by conventional reagents is usually extremely difficult to achieve, and

the ease of breakdown by photochemical oxidation indicates a novel chain reaction visualized, after taking other evidence into consideration, as follows:

$$C_3F_7I \xrightarrow{h\nu} C_3F_7\cdot \xrightarrow{O_2} C_3F_7\cdot O_2\cdot \xrightarrow{C_3F_7I} C_3F_7.O.OI$$

$$C_3F_7.O.O.I \xrightarrow{h\nu} C_3F_7.O\cdot + \cdot OI$$

$$C_3F_7.O\cdot \longrightarrow C_2F_5\cdot + COF_2$$

$$C_2F_5\cdot \xrightarrow{O_2} C_2F_5.O_2\cdot \xrightarrow{C_3F_7I} C_2F_5.O.OI \longrightarrow C_2F_5\cdot O\cdot$$

$$C_2F_5\cdot O\cdot \longrightarrow COF_2 + CF_3\cdot \xrightarrow[\text{etc.}]{O_2,C_3F_7I} COF_2\ (+SiF_4)$$

Such a branching chain mechanism, involving formation of perfluoroalkoxy radicals such as $C_3F_7.O\cdot$, $C_2F_5\cdot O\cdot$ and $CF_3\cdot O\cdot$ followed by loss of COF_2 to give a perfluoroalkyl radical of shorter chain-length, makes understandable a reaction that was initially quite anomalous in fluorocarbon chemistry[2].

(2) Heptafluoronitrosopropane is obtained when heptafluoroiodopropane is photolysed in the presence of nitric oxide[3,4]. In the absence of mercury, which removes from the reaction zone the nitrogen dioxide produced by photolysis of nitric oxide, the formation of heptafluoronitrosopropane is accompanied by the production of heptafluoronitropropane and by extensive breakdown of the perfluoroalkyl chain to give carbonyl fluoride and low yields (2–5 per cent) of pentafluoronitrosoethane and trifluoronitrosomethane as well as smaller amounts of the corresponding nitrocompounds. The formation of nitroso- and nitroderivatives of the shorter-chain radicals C_2F_5 and CF_3 is best explained as follows[4]:

$$C_3F_7I \xrightarrow{h\nu} C_3F_7\cdot + I\cdot$$

Formation of nitroso-compound:

$$C_3F_7\cdot + NO \longrightarrow C_3F_7.NO$$

Formation of nitro-compound:

$$C_3F_7\cdot + NO_2 \longrightarrow C_3F_7.NO_2$$

Formation of nitrite:

$$C_3F_7\cdot + NO_2 \longrightarrow C_3F_7.O.NO$$

Chain degradation *via* alkoxy radical:

$$C_3F_7.O.NO \xrightarrow{h\nu} C_3F_7.O\cdot + NO$$

$$C_3F_7.O\cdot \longrightarrow C_2F_5\cdot + COF_2$$

$$C_2F_5\cdot + NO \longrightarrow C_2F_5.NO$$

$$C_2F_5\cdot \xrightarrow{NO_2} C_2F_5.O.NO \xrightarrow{h\nu} C_2F_5.O\cdot \longrightarrow$$

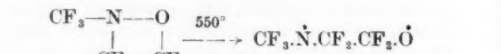
$$COF_2 + CF_3\cdot \xrightarrow{NO} CF_3.NO$$

$$CF_3\cdot \xrightarrow{NO_2} CF_3.O.NO \xrightarrow{h\nu} CF_3.O\cdot \xrightarrow{SiO_2} COF_2 + SiF_4$$

that is, by formation of the nitrite, which undergoes O—N fission to give a perfluoroalkoxy radical; this, in turn, gives a perfluoroalkyl radical of shorter chain-length.

Similar breakdown of the perfluoroalkyl chain is observed when heptafluoroiodopropane is irradiated in the presence of nitrogen dioxide, since $C_3F_7.NO_2$ (38 per cent), $C_2F_5.NO_2$ (7 per cent), and $CF_3.NO_2$ (17 per cent) are produced as well as carbonyl fluoride[4].

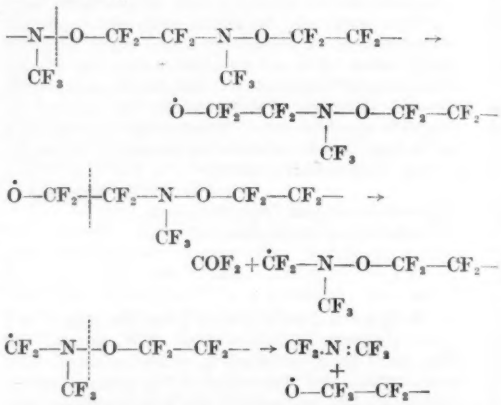
(3) Trifluoronitrosomethane reacts with tetrafluoroethylene to give, quantitatively, perfluoro-2-methyl-1 : 2-oxazetidine (I) and a polymer of formula $-[\cdot N(CF_3).O.CF_2.CF_2.]_n-$ and molecular weight greater than 7,000[4]. Pyrolysis of the oxazetidine, or of the polymer, gives, quantitatively, equimolar amounts of perfluoro(methylenemethylamine), $CF_3.N : CF_2$, and carbonyl fluoride. Heptafluoronitrosopropane and tetrafluoroethylene react in a similar manner[4]. These pyrolyses are readily explained if it is assumed, not implausibly, that N—O fission occurs initially, since carbonyl fluoride elimination from the resultant perfluoroalkoxy radical would be the next step:



(I)

$$CF_3.\dot{N}.CF_2.CF_2.\dot{O} \longrightarrow COF_2 + CF_3.\dot{N}.\dot{C}F_2 \longrightarrow CF_3.N : CF_2$$

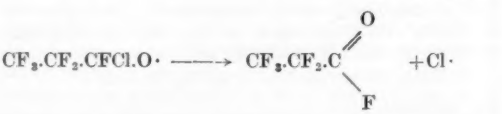
and similarly



It does not follow from the above three examples that all perhalogenoalkoxy radicals will decompose by elimination of COX_2. There is already some evidence[2] that when chlorine or bromine is present as well as fluorine on the carbon next to the oxygen atom, a chlorine or bromine atom is expelled in preference to carbonyl halide elimination; for example[2],

$$CF_3.CF_2.CFClI \xrightarrow{h\nu} CF_3.CF_2.CFCl\cdot \xrightarrow{O_2} CF_3.CF_2.CFCl.O_2\cdot$$

$$CF_3.CF_2.CFCl.O_2\cdot \xrightarrow{CF_3CF_2CFClI} CF_3.CF_2.CFCl.O.OI \xrightarrow{h\nu} CF_3.CF_2.CFCl.O\cdot$$



so that breakdown of the chain is prevented and products useful for synthesis can thus be obtained. Doubtless other modes of decomposition of these reactive and useful poly- and per-halogenoalkoxy radicals will be found. [Dec. 14

[1] See, for example, Adler, Pratt and Gray, *Chem. and Indust.*, 1517 (1955); Levy, *J. Amer. Chem. Soc.*, **75**, 1801 (1953).
[2] Haszeldine and Francis, *J. Chem. Soc.*, 2151 (1955).
[3] Haszeldine, *Nature*, **168**, 1028 (1951); *J. Chem. Soc.*, 2075 (1953). Haszeldine and Jander, *J. Chem. Soc.*, 912, 919, 696 (1954).
[4] Barr and Haszeldine, *J. Chem. Soc.*, 1881 (1955); *J. Chem. Soc.* (in the press); *Nature*, **176**, 991 (1955).

LETTERS TO THE EDITORS

The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications.

Genetic Effects of X-Rays in Relation to Dose-rate in *Drosophila*

VARIATION in dose-rate has generally been observed to be ineffective in determining the incidence of mutations and structural changes produced by X-rays in *Drosophila* spermatozoa[1]. However, since it is now clear that a considerable fraction of the genetic damage brought about by radiation results from an indirect path of action, intensity effects might be expected to operate under certain conditions. Chemical mutagens induced by radiation must have a finite life-span before they are removed or rendered ineffective by one or another metabolic pathway. Therefore very high dose-rates, leading to an accumulation of mutagens, should effect a greater amount of damage as a result of diffusion of the active substances to other regions within the nucleus. Sobels's observations[2] that pretreatment with cyanide or azide increases the yield of sex-linked lethals obtained from irradiated *Drosophila* males suggests that the accumulation of chemical mutagens can be facilitated by the concurrent use of suitable enzyme inhibitors.

Haas *et al.*[3] have indeed reported recently that they observed an intensity effect while studying the production of translocations in *Drosophila* sperm. Using dose-rates of 100 r./min. and 2,000 r./min., we have been able to confirm that, for a given dose, a greater amount of genetic damage is produced if the radiation is delivered at high intensity. With a total dose of 2,000 r., the high dose-rate gives an increase of up to 25 per cent in the yield of recessive sex-linked lethals and of translocations. If, just prior to irradiation, the flies are injected with 0·005 *M* sodium azide in saline, the intensity effect is enhanced. The figures in Table 1 illustrate the effects of such an injection on the production of sex-linked recessive lethals by 2,000 r. of X-irradiation delivered to spermatozoa within the spermathecæ of inseminated females.

An especially interesting feature of high-intensity treatment is the production of numerous F_1 females that prove to be mosaics for a sex-linked lethal. By subculturing a single female from those F_2 cultures which fail to yield a lethal, a further crop of mutations may be obtained in the F_2 generation at a frequency of about one-tenth that observed in the preceding generation. This delayed appearance of lethals recalls the similar effects produced by chemical mutagens such as mustard gas[4]. Delayed mutations may also be obtained by mating males that have received high-intensity radiation to attached-*X* females and then crossing the F_1 males to Muller-5 females in the usual way. It should be emphasized

Table 1. SEX-LINKED LETHAL MUTATION-RATE

Dose-rate	Inseminated females received 2,000 r. preceded by an injection of 0·2 μl. of:	
	0·7 per cent NaCl	0·005 *M* NaN_3 in 0·7 per cent NaCl
100 r./min.	6·3% ± 0·8	7·6% ± 1·0
2,000 r./min.	8·4% ± 0·6	13·1% ± 1·2

Table 2. PRODUCTION OF HYPERPLOID FEMALES

Treatment	Total No. females	Hyperploids	Standard error	P
A	1,875	1·07%	0·24	
B	1,718	1·16%	0·26	= 0·3
C	1,772	1·52%	0·29	< 0·01
D	2,316	0·52%	0·15	

A, undivided dose; *B*, four equal fractions, 1 min. between each; *C*, four equal fractions, 5 min. between each; *D*, four equal fractions, with a 30-min. interval between each. Temperature, 16° C. Total dose, 4,000 r.

that such delayed effects are quite rare if the same dose of radiation is administered at an intensity less than 1,000 r./min. Further study is needed before it can be decided whether the lethals recovered in the F_2 generation are really instances of delayed mutation or whether they are the result of partial breakage of a multi-strand chromosome, followed by sorting out of a mixture of broken and unbroken chromonemata.

In an attempt to estimate the duration of life of the active substances produced by the high-intensity irradiation, fractionation experiments were carried out with varying time-intervals between successive treatments. The experiments were scored by recording the proportion of hyperploid females obtained from a single 24-hr. mating of attached-*X* females (homozygous for the recessive gene, yellow) to Canton *S* males that had received a total dose of 4,000 r. delivered at high intensity (Table 2). At a temperature of 16° C., division of the dose into four equal fractions does not reduce the incidence of hyperploids obtained unless the time-interval between successive doses of radiation is more than five minutes. The critical time-interval would, of course, be expected to be related to the magnitude of each fractional dose, but clearly the effects may persist long enough for further experimental analysis to be practicable.

Full details of this work will be published elsewhere.

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University of Melbourne.
Jan. 6.

[1] Muller, H. J., "Radiation Biology", edit by A. Hollaender, chapter 8 (McGraw-Hill, New York, 1954).
[2] Sobels, F. H., *Z. indukt. Abstammung u. Vererbl.*, **86**, 399 (1955).
[3] Haas, F. L., Dudgeon, Edna, Clayton, F. E., and Stone, Wilson S., *Genetics*, **39**, 453 (1954).
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A Ventral Ectodermal Ridge of the Tail in Mouse Embryos

THE limb buds of mammalian and avian embryos show a thickening of the ectoderm on the margin of the foot plates, the so-called apical ectodermal ridge, and it is known that this ridge plays an important part in the growth and differentiation of the limbs[1,2]. It has recently been discovered that a similar thickening of the ectoderm is present on the ventral side of the tail in 10- and 11-day old mouse embryos. In 10-day old embryos (crown-rump length 3·4–4·2 mm.; lens invaginations still widely open), there occurs a very conspicuous zone of columnar epithelium on the ventral aspect which extends from the very tip of the tail in a proximal direction for roughly 250 micra; the exact length of the zone is difficult to determine as it gradually disappears

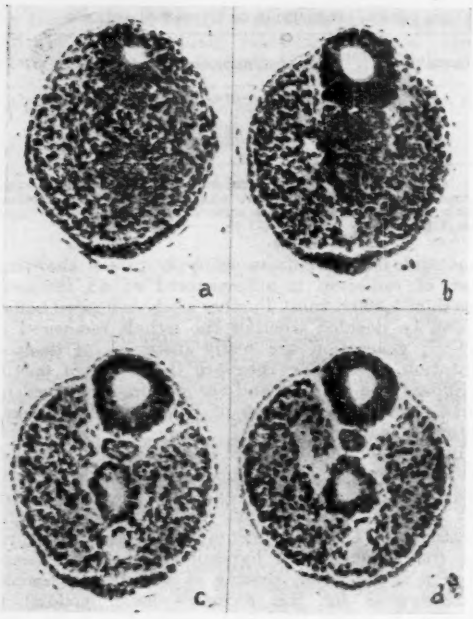

Fig. 1

proximally. The accompanying photomicrographs (Fig. 1) are four transverse sections through the tail of such an embryo (crown-rump length 4·1 mm.; Bouin fixation; hæmatoxylin and eosin; 7·5 micra; × 125) at intervals of about 68 micra; (*a*) is the most distal and (*d*) the most proximal of these sections. The columnar zone of epithelium is obvious in the first three sections but has disappeared in the fourth. In 11-day old embryos (crown-rump length 5·3–5·7 mm.), the structure is rather less conspicuous, and in one out of three such embryos it occupied a position somewhat proximal to the tail tip. In 12-day old embryos the structure has virtually disappeared.

In 9- and 9½-day old embryos (crown-rump length 2–3 mm.), the origin of the ventral ectodermal ridge is traceable to the cloacal membrane. Where entoderm and ectoderm are in direct contact, the latter assumes a columnar structure. Soon afterwards, as the tail bud elongates, the columnar zone spreads in a distal direction; the continuity between ventral ectodermal ridge and cloacal membrane is lost in embryos of about crown-rump length 3 mm.

That the ventral ectodermal ridge of the tail may have a function comparable to that of the apical ectodermal ridge of the limb buds is suggested by the following fact. In the recessive mutant vestigial-tail (*vt*) in the mouse[3], there is almost no tail in the adult except for a short stump or a thin filament. A rudimentary tail (which disappears again later in development) is present in 10-day old embryos, but this rudimentary tail of vestigial embryos has a greatly reduced ventral ectodermal ridge. The situation thus seems similar to the gene for wingless in the domestic fowl[4], where the apical ectodermal ridge of the anterior limb buds is missing or greatly reduced.

There exists in the mouse a type of anomaly which can be brought about by a variety of genotypes, the uro-recto-caudal syndrome[5]; in affected animals, defects of derivatives of the cloaca are associated with reduction or absence of the tail. It may be suggested that cloacal and caudal defects occur together because of the origin of the ventral ectodermal ridge of the tail from the cloacal membrane.

A detailed account of this work will be published elsewhere.

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A New Muscle Preparation for the Study of Optical Changes during Contraction

Live squid muscle is remarkably transparent. Sereni and Young[1] noted that it becomes more opaque when stimulated. We find that in healthy living muscle the increase in opacity is only transient and that even in response to single shocks this phenomenon is visible to the naked eye. It is therefore easy to record, and thus makes squid muscle particularly suited for studies of optical changes during contraction. Such work is now in progress.

Preliminary experiments have been done on board the research ship *Sarsia* with freshly caught animals. After decapitation, removal of the stellate ganglia and of the skin covering the mantle, a rectangular piece of mantle muscle was cut out and pinned securely under sea water in the path of a parallel beam of light. A vacuum photocell mounted about two inches above the muscle recorded on a cathode ray tube the changes in light transmitted in the incident direction. Square-wave stimuli were applied by means of platinum electrodes to nerves innervating the area of muscle under observation. Mechanical changes were recorded isometrically with an *RCA* 5734 transducer. Records could be obtained within three minutes of killing the animal and nerve-muscle preparations remained in good condition for several hours. The threshold for stimulation of the preparation is approximately 0·3 volt, 150 μsec. width.

The opacity changes during a twitch are shown in Fig. 1, together with electrical (muscle action potential) and mechanical (tension) changes. About 30 per cent more of the light is scattered at the peak of the twitch. At high amplification an initial small decrease in opacity is observed (Fig. 1,*a*); it coincides with the falling phase of the action potential (Fig. 1,*b*) and precedes the first sign of tension change. The latency for opacity decrease at room temperature is about 12 m.sec., the peak of the decrease being reached within 22 m.sec., while the first sign of tension change occurs at 19 m.sec. (These values include nerve conduction time.) The early opacity decrease corresponds to a similar phenomenon observed by Hill[2] in frog muscle where it starts at the same time as latency relaxation. However, in squid muscle, we can find no sign of latency relaxation—if it exists it must be less than 10^{-5} of the twitch tension (in frog muscle the early tension drop is about 10^{-3} of twitch tension[3]). The absence of latency relaxation has already been noted in other molluscan muscles[4].

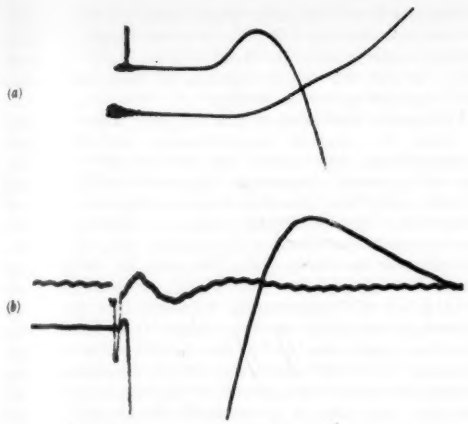

Fig. 1. Responses of squid mantle muscle to single shocks. Records read from left to right. *a*, upper trace: opacity change (increase downwards); lower trace: development of tension (increase upwards). Duration of sweep, 50 m.sec. *b*, upper trace: muscle action potential; lower trace: opacity change recorded at lower amplification than in (*a*). 50 c./s. oscillation imposed on upper trace. (Note that in (*b*) the trace of the optical change at the end of the twitch crosses the base-line: this is an artefact due to recording with a condenser-coupled amplifier)

We are grateful to Prof. A. L. Hodgkin and Dr. R. D. Keynes for directing our attention to the transient nature of opacity changes in squid muscle, and to Mr. F. J. Warren for his unfailing assistance. Part of the electrical apparatus was purchased with a grant from the Royal Society.

Note added in proof. Polar diagrams of the light scattered by resting and active mantle muscle have now been obtained. There is a decrease in transmitted light at angles less than about 15° to the incident direction and the phenomenon is reversed at greater angles.

The early opacity change is not due to diffraction: the muscle is unstriated and shows no regular diffraction bands.

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Phospholipid Metabolism of Skin

During work on the metabolism of skin, it was found that a scissors mince of rat skin could incorporate phosphoric acid-^{32}P into the lipid fraction. On completion of the work, our attention was directed to the work of Leonhardi *et al.*[1], who had found no *in vitro* synthesis of phospholipid, and had concluded as the result of this and some *in vivo* feeding experiments that rat skin depended for supplies of phospholipid on the liver via the blood. In view of Zilversmit's[2] comment that "rat skin has been shown to be one of the few tissues that cannot synthesize its own phosphatides *in vitro*", it has been thought desirable to record some contrary observations that have been made. The point is obviously of major importance in the metabolism of skin.

The abdominal skin of male albino rats was mechanically clipped and carefully scraped free from subcutaneous tissue, which has a distinctive pink tinge. A scissors mince was prepared, of which 100–400 mgm. portions were incubated at 34° in Krebs–Henseleit saline containing 10 m.molar substrate and 5 μc. phosphoric acid. Each animal yielded about 1 gm. of mince. At the end of the experimental period sufficient 100 per cent (w/v) trichloracetic acid was added to bring the final concentration to 5 per cent, and the mince was washed thrice more with 5 per cent trichloracetic acid. Two water washes removed most of the acid. Lipid was extracted by either of two procedures: (1) three 1-hr. refluxings with ethanol–ether (3 : 1, v/v), evaporation to dryness in the presence of 1 ml. *M* disodium hydrogen phosphate and re-extraction with chloroform; (2) three 1-hr. refluxings with chloroform–methanol (1 : 1, v/v) followed by a wash with 0·1 *N* hydrochloric acid[3]. The final chloroform extract was made to 10 ml. and portions taken for determination of lipid-phosphorus[4].

The radioactivity of the resulting blue solutions was measured in a liquid counter. In every set of experiments a zero-time control was run, in which the trichloracetic acid was added at the beginning. The fact that the specific activity of the lipid-phosphorus of this control never exceeded 5 per cent of that of the 3-hr. experimental portion with glucose as substrate shows that the procedures effectively removed contaminating acid-soluble phosphorus. The rate of synthesis of phospholipid during the first four hours is shown in Fig. 1, and some results with different substrates and inhibitors in Table 1.

The discrepancy with the *in vitro* findings of Leonhardi *et al.*[1] is difficult to explain. Unfortunately, pressure of other work has prevented repetition of some of the work using their technique, and of any of the *in vivo* work. Consequently a full discussion of their results and conclusions would be out of place, although attention is directed to two points. First,

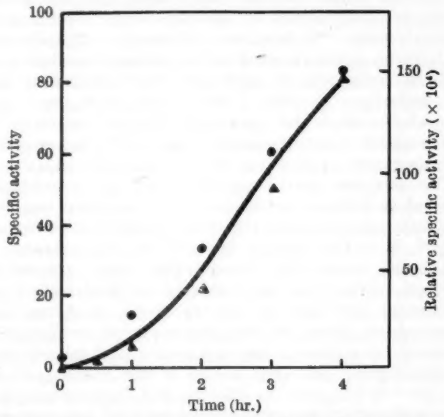

Fig. 1. Time-course of incorporation of phosphorus-32 into rat skin lipids *in vitro*. Specific activities, counts/min./μgm. lipid-phosphorus, uncorrected. Relative specific activities, ratios of specific activity of lipid-phosphorus to that of acid-labile phosphorus (trichloracetic acid extract) of saline medium. Two separate experiments

Table 1. The Synthesis of Phospholipid by Rat Skin *in vitro*

Substrate (10 m.molar)	Percentage specific activity of lipid-phosphorus in 3 hr. relative to glucose
No substrate	69 (87, 59, 62)
Succinate	72 (79, 87, 50)
Glycerol	68
L-Malate	45 (44, 39, 53)
DL-Lactate	52
Acetate	53
Oleate	31 (15, 44, 30, 16, 52)
Palmitate	44
Stearate	42
Glucose, anaerobic	19 (18, 15, 23)
Glucose, iodoacetate (1 m.molar)	11 (6, 15)

the criteria deduced by Zilversmit *et al.*[5] for showing the derivation of a substance from its immediate precursor are not obeyed by the data of their Fig. 2. Hence it is difficult to argue that liver phospholipid is the precursor of skin phospholipid. Secondly, conclusions from an experiment involving the feeding of labelled phospholipid are drawn from observations at a single point of time, 48 hr. Reiner[6] has argued that, in tracer work, observations at a single point of time are often susceptible to more than one interpretation. It seems likely that if Leonhardi *et al.*[1] had not failed to demonstrate *in vitro* synthesis of phospholipid by skin, they could have placed an entirely different interpretation on their *in vivo* experiments.

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Enzymic Synthesis and Properties of a Polynucleotide from Adenosine Diphosphate

The well-known viscous nature of solutions of lysed cells of *M. lysodeikticus*, attributed in part to nucleic acids, led to the search for an active nucleotide polymerase in this organism. Preliminary studies with ^{14}C-labelled adenosine diphosphate (ADP) (the initial paper chromatographic studies were done in collaboration with Dr. Peter Olmsted) and the technique described by Grunberg-Manago and Ochoa[1] revealed the presence of such an enzyme. The present communication deals with the enzymic synthesis and properties of the polymer $(AMP)_n$.

The enzyme has been obtained in a partially purified and highly active form from aqueous extracts of lysed cells fractionated with ammonium sulphate at *p*H 8. The major portion of the activity is associated with the 30–40 per cent saturation fraction. The enzyme activity is determined by measuring the rate of formation of acid-insoluble material or rate of disappearance of acid-soluble material. A typical assay consists of a 2-ml. mixture containing 10^{-3} *M* ADP, 0·025 *M* tris buffer, *p*H 10, 5×10^{-3} *M* magnesium chloride and dialysed enzyme. The reaction is stopped at the end of ten minutes with the addition of 2 ml. of 5 per cent perchloric acid. The precipitate is centrifuged down, washed once with perchloric acid and twice with 95 per cent ethanol, and finally dissolved in 3 ml. of 0·1 *M* tris buffer, *p*H 8·0. The absorption peak of the solution is then measured at 257 mμ. A usual range of optical density values may be from 0·1 to 1·0. A blank which is run for determination of bacterial nucleic acid may be as low as 0·025.

The rate of synthesis of the polymer is proportional to both the enzyme concentration and the ADP concentration, the latter up to 5×10^{-3} *M*. The rate of polymer formation appears to follow zero kinetics until the reaction is more than 90 per cent completed. However, the picture is complicated by the action on ADP of a myokinase and possibly a phosphatase in the enzyme preparation. Chromatographic studies of the reaction mixture consistently reveal a low ATP/AMP ratio. Nevertheless, the results are consistent with the hypothesis that the enzyme has a stronger affinity for the polymer than for the monomer and that once the initial conditions have established the maximum concentration of the polymer, the rate is afterwards determined by the 'product' rather than by the 'substrate'. The reaction will not take place in the absence of magnesium chloride. The *p*H optimum of the reaction depends upon the concentration of magnesium chloride but is greater than 10 at low concentrations. The activation energy over the temperature-range of 8–39° is 11·8 k.cal. at *p*H 8. An apparent equilibrium is in favour of the polymer to the extent of about 70 per cent at *p*H 10 and 37° (it decreases with lower *p*H); but it is independent of enzyme or magnesium chloride concentration. Inorganic phosphate (dipotassium hydrogen phosphate) at concentrations of 0·01 *M* strongly inhibits the polymerization reaction and brings about a rapid decrease in the amount of polymer formed when added to the reaction mixture. The viscosity of the reaction mixture increases at a rate which depends in part on the experimental conditions; but under optimal conditions the viscosity increment may exceed 500 per cent and be only partially dependent upon the amount of polymer formed. Addition of inorganic phosphate brings about a rapid decrease in viscosity. The enzyme preparation is also active with other nucleotide diphosphates in the following order of rates: CDP>ADP>UDP$\gg$GDP (no activity at 10^{-3} *M* concentration).

The polymer has been isolated in relatively pure form and subjected to several physical-chemical studies. Its absorption spectrum is similar to that of AMP, but the peak is shifted to 257 mμ and the extinction coefficient is reduced approximately 50 per cent. Addition of a strong alkali such as sodium hydroxide results in a progressive hydrolysis of the polymer associated with a sharp increase in the absorption throughout the ultra-violet range. The polymer readily dissolves in water or alkaline solution to form highly viscous solutions from which gossamer threads can be spun. In a semi-dried state it forms a rubber-like mass which can be stretched to give a well-oriented birefringent structure. X-ray diffraction studies are being made of the spun fibres. The sedimentation coefficient of one preparation at a concentration of approximately 0·007 per cent was 16×10^{-13} at 20°. Electron micrographs show unbranched chains, similar in many ways to those of DNA but irregular in width and smaller in diameter. A Zimm plot of data from light-scattering studies of another preparation showed a molecular weight of $1{\cdot}86 \times 10^6 \pm 20$ per cent with a length of 2400 A. (assuming monodispersed material).

These results should be compared with those previously reported from Dr. Ochoa's laboratory[1,2].

The ease of reversing the polymerization reaction supports the thesis that the primary biological role of RNA may be that of a source of readily available high-energy polyphosphate mononucleotides. The enzyme preparation displays a very strong phosphorylase activity toward the nucleic acid of the bacterium.

This investigation was supported by Research Grant *C*-2550 from the National Cancer Institute, National Institutes of Health, U.S. Public Health Service. I wish to acknowledge the technical assistance of Mrs. G. Olson in this study and the generous co-operation of the following persons who carried out the work on the polymer: X-ray diffraction studies were under the supervision of Dr. R. S. Bear with Dr. R. S. Morgan; ultracentrifugation studies were made by Dr. D. A. Yphantis; electron microscopy studies were under the supervision of Dr. C. E. Hall; and the light-scattering measurements were made by Dr. R. F. Steiner.

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Effect of Pinealectomy on the Rat Pituitary

PINEALECTOMY in rats has been variously reported as resulting in no change[1] or as causing a hypertrophy of the pituitary, with an increase in the proportion of acidophils of the anterior lobe, and some degeneration of the basophils[2].

Blind subdural pinealectomy has been attempted on a small series of young male rats, aged two to four months. Those surviving the operation were killed six to twelve weeks afterwards. Histological examination of the brain confirmed that in eight animals the pineal body had been totally removed, whereas in the remaining seven it was still in its normal position, and apparently undamaged. The pituitary bodies of these two series of animals were fixed in Zenker-formol, sectioned and stained by Pearse's method[3]. Modified Rasmussen[4] cell counts of the anterior lobes were then made, approximately five thousand cells being counted in each gland. The results are shown in Table 1.

These figures show that there is no significant difference between the cellular constitution of the anterior lobe of the pituitary of pinealectomized and non-pinealectomized animals. Successful removal of the pineal did not give rise either to a marked increase in the numbers of acidophils or to basophil degeneration. Colloid formation and development of 'signet ring' forms in the basophils were not significantly increased.

Table 1

	Mean percentages ± mean standard error	
	Pinealectomized	Non-pinealectomized
Acidophils	42·2 ± 1·6	41·3 ± 1·3
Basophils	6·0 ± 0·8	6·6 ± 0·8
Chromophobes	51·8 ± 1·7	52·1 ± 0·8
Percentage of basophils showing colloid formation	4·3 ± 1·6	2·7 ± 1·1

These findings indicate that the pineal body has no effect on the anterior lobe of the pituitary of the young male rat, and suggest that if gonadal changes such as have been reported[5] do occur, they are not mediated via the pituitary.

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Incomplete Wound Contracture and the Phenomenon of Hair Neogenesis in Rabbits' Skin

IN rabbits, the healing of extensive wounds produced by excision of the full thickness of the skin of the trunk is the outcome of two distinct, though to some extent overlapping, processes which provide in turn a temporary and a definitive repair[1]. During the course of the first week or two, the defect becomes filled with granulation tissue, which is progressively epithelialized by the migratory ingrowth of epithelium from the wound margins. Closure of the raw tissue surface in this manner marks the completion of temporary repair. The definitive repair is brought about by contracture, a forced inward movement of the wound margins as a consequence of tensile forces generated within the substance of the granulation tissue or its derivatives[2]. Contracture, so it has been shown, is accompanied by a compensatory expansion of the integument surrounding the wound through intercalary or intussusceptive growth[1].

Recent experiments by Billingham and Russell[3] have shown that the process of contracture in experimental full-thickness wounds, ranging in area from about 10 cm.^{2} to 50 cm.^{2} and of various shapes, including rectangles and circles, proceeds at a constant specific rate; that is, obeys the exact opposite of the familiar compound interest law of growth. The logarithm of the area of a wound decreases linearly with time, at least until the wound is not more than a few square centimetres in extent. The actual values of the specific rates of contracture fell within the range 5–8 per cent of the wound area per day. In one series of extensive wounds, 20–40 cm.^{2} in area, produced by excision of the full thickness of the skin down to, but not through, the panniculus on the trunks of thirty-two full-grown rabbits, contracture approached its theoretical end-point so closely in nineteen (that is, about 60 per cent) that only a narrow linear scar remained. In these animals the re-apposition of the skin of the original wound margins was virtually complete. In the remaining thirteen animals, however, the process of contracture terminated abruptly after the areas of their wounds had been reduced to about 5 cm.^{2} or less.

Incomplete wound contracture was also observed in a further group of seven animals, of which three had been adrenalectomized before the excision of their cutaneous wounds, and four received daily administrations of 10 mgm. of cortisone acetate,

commencing on the day of operation and continued for at least thirty days. Besides slowing down the rate of contracture, both treatments greatly increased the incidence of incomplete contracture.

Once their contracture had terminated prematurely, the areas of most of the wounds underwent very little change. Their margins remained incisive. In a few animals it was observed that incompletely contracted wounds actually underwent a slow expansion, attaining by about the hundredth day a final area which was approximately double the minimum which contracture had produced by about the fiftieth day.

We have observed that from the smooth, bald surfaces of all incompletely contracted wounds fine hairs begin to emerge, commencing at the periphery, within about forty to fifty days of the operation. The time of appearance of these hairs seemed to depend, among other things, upon the age of the subject: in a group of three animals which were only fifty days old when their wounds were prepared, new hairs had already begun to pierce the surface as soon as the twenty-ninth day. With the production of these hairs the originally smooth scars may be said to have become transformed into a sort of *ad hoc* skin. The hair crop was invariably white in colour, despite the fact that all the rabbits used were of pigmented breeds. The orientation of the hairs borne by these scars bore no constant relation to that of the fur of the adjacent normal skin; the new hairs sloped outwards from the centres of the scars. Comparison of actual counts showed that the hair densities on the scars did not differ significantly from those on neighbouring normal skin. So far as we have been able to ascertain, guard hairs were not included among the newly formed hairs, which, like those of normal skin, were grouped together in small follicle clusters.

The only striking anatomical imperfection of these new hair follicles was their apparent lack of arectores pili muscles. The hairs were medullated and well-developed sebaceous glands were invariably present.

In the preparation of these experimental wounds particular care was taken to remove all trace of the dermis from the surface of the panniculus, including, of course, any embedded follicle bases. When this fact is taken into consideration, together with the large number of new hairs formed (up to 3,500), it leads unequivocally to the conclusion that the hairs were of new formation and could not possibly have been derived from pre-existing follicle remnants. This conclusion is strongly reinforced by their uniform lack of pigment, which is highly suggestive of an origin from the superficial as opposed to follicular epidermis.

The hairs on these uncontracted wounds persisted throughout the entire period of observation, which rarely fell short of a hundred days and frequently exceeded 150 days. Grafting experiments provided further evidence as to the permanence and stability of the new 'skin'. For when small full-thickness grafts were removed from it and transplanted elsewhere on an animal's body, they invariably healed in satisfactorily and regenerated new hairs of the original type.

The new hair-bearing skin was chronically œdematous and slightly inflamed, enlarged blood vessels being particularly prominent in sections; its thickness was about twice that of normal skin; it had a somewhat soft, cheesy consistency when incised, lacking the toughness characteristic of normal skin, and its collagen fibres were mainly disposed in a horizontal plane as is usual in scar tissue.

That the phenomenon of hair neogenesis has escaped notice for so long is probably attributable to the high proportion of wounds which undergo complete contracture and the fact that, even in rabbits whose wounds fail to contract completely, hairs do not normally appear on the scars for many weeks. It may be added that the great majority of previous wound-healing studies have been based on undressed wounds, in which contracture normally takes place much more rapidly and completely, as we have shown[3]. Here the final conditions are most unfavourable for the formation of new hairs. In all the experiments reported on here, the wounds were maintained under dressings at least until they were completely epithelialized and the epithelium was firmly united to its bed and sufficiently robust to withstand the trauma of everyday life. In no animals were the dressings left off before the thirtieth day.

The first unequivocal evidence of the occurrence of hair neogenesis in adult rabbits was presented by Breedis[4], who realized the necessary experimental conditions when he mechanically inhibited the contracture of full-thickness cutaneous wounds by the insertion of appropriately shaped metal splints. Our own findings are in complete accord with his.

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Muscular Dystrophy of Beef Cattle and Unsaturated Fats

The enzootic muscular dystrophy of suckling beef cattle in the north of Scotland[1] can be prevented by administration of α-tocopherol[2]. Analyses of rations which consist mainly of turnips and straw show them to be deficient in tocopherol, and this dietary lack is reflected in extremely low concentrations of tocopherol in the blood serum, colostrum and milk of the cow, and in the blood serum and the tissues of her calf[3]. The quantity of tocopherol necessary for the prevention of the disease in the suckling calf is, however, much higher (twice) than that required by experimental calves given artificial rations simulating milk. Since unsaturated dietary fats such as lard[4] and especially cod-liver oil[5] (a particularly rich source of polyethenoid fatty acids) lead to a gross exacerbation in the incidence and severity of muscular dystrophy and to considerable increases in tocopherol requirement, it was thought that the nature of the dietary fat ingested by the calves in the north of Scotland might be a further factor, in addition to a low tocopherol intake, accounting for the incidence of the disease. This hypothesis was supported by the finding that it was not possible to produce muscular dystrophy experimentally in calves when they were given rations low in tocopherol content but free of fat[6].

Table 1. Tocopherol Content of Cows' Serum and Milk and Analysis of Milk Fats

Diet (excluding straw)	Mean tocopherol content of blood serum of cows (μgm./100 ml.)	Mean tocopherol content of milk fat (mgm./gm.)	Iodine value of milk fat	Unsaturated acids in milk fat (mol. per cent)			
				C_{16}–C_{18}	Oleic	C_{18} di- and tri-enoic	As C_{20}–C_{22}
Silage	299	38	41·0	5·2	28·7	1·3	2·3
Silage plus turnips	293	22	36·0	4·6	22·6	1·7	1·9
Turnips	117	4	36·6	7·4	21·0	1·5	0·9
Turnips	94	5	30·4	7·4	16·0	1·5	0·6

The composition of the mixed fatty acids derived from the milk fat of groups of cows in the north of Scotland given rations of turnips and straw was determined by ester-fractionation and compared with that of similar cows in the area given rations containing grass silage. In the latter group the incidence of dystrophy in the offspring is rare. The concentration of polyethenoid fatty acids in the serum lipids of the calves of the cows in the two above groups was also determined according to Wiese and Hansen[7]. Salient information on the composition of the milk fats is given in Table 1.

The low tocopherol content of the blood serum and milk of cows given rations of turnips and straw was not, however, associated with a greater degree of unsaturation of the milk fats; on the contrary, the fats contained less of the unsaturated fatty acids in the C_{20}–C_{22} series and less oleic acid than the milk fats of the cows given silage. There was a corresponding increase in the concentration of saturated acids in the C_4–C_{16} series, especially in respect of palmitic acid.

The concentrations of polyethenoid fatty acids in the blood serum lipids of the calves of cows given turnips and straw were lower if anything than in the serum lipids of calves from cows given silage, as shown in Table 2.

Table 2. Proportion of Polyethenoid Acids in Blood Serum Lipids of Suckling Calves

Unsaturated acids	Proportion (wt. per cent) of acids in serum lipids of calves, the dams of which were fed on	
	Silage	Turnips and straw
Tetraenoic	3·42	3·45
Trienoic	3·95	3·25
Dienoic	10·23	7·63

There was no indication that abnormal amounts of polyethenoid acids were present in the blood serum lipids of susceptible calves. Experiments with seventy-five calves showed that daily supplements of 20 mgm. α-tocopherol per calf led to slight reductions in the concentration of the unsaturated acids in the blood serum lipids. For calves receiving the unsupplemented ration, the average concentrations (weight per cent) of tetraenoic, trienoic and dienoic acids in the serum lipids were 3·8, 3·7 and 9·1 respectively, and for calves receiving the supplemented ration 3·2, 3·5 and 8·4 respectively. These differences, though they suggest that tocopherol reduces the concentration of polyethenoid acids in the serum lipids, were not statistically significant.

As already mentioned, the importance of dietary sources of unsaturated fat in determining tocopherol requirements in experimental calves is now well established[4–6]. The present work shows that in enzootic muscular dystrophy, the milk fat which the calves receive is less unsaturated than that received by calves which do not usually develop the disease. The fat is, however, grossly deficient in tocopherol content, and this is clearly a more important consideration than the presence of abnormally large amounts of unsaturated fatty acids in accounting for the incidence of dystrophy. The sporadic incidence of the disease, its correlation with muscular exercise and the relatively high tocopherol intakes necessary for complete prevention remain to be explained.

Detailed accounts of this work will be published elsewhere.

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Avidity of the Water-soluble Components of Herbage for Added Cupric Ions

During work to investigate the availability of organic complexes of copper to the copper-deficient rat, it was found possible to demonstrate the existence of stable copper complexes formed by adding copper-64 ions to the water-soluble components of herbage.

On filter-paper chromatograms developed with phenol/water, a number of complexes of copper with amino- and hydroxy-acids have been shown to have R_F values in the range 0·08–0·98, whereas the R_F of the free cupric ion in this solvent has not been found to exceed 0·06. It is apparent that this technique can provide a useful indication of whether or not the copper in a biological fluid is present as the free ion.

To investigate the effect of adding cupric ions to the water-soluble components of herbage, 2 gm. of freeze-dried grass was extracted with 20 ml. water at 37° C. for 14 hr. After centrifuging at 25,000 *g* for 30 min., 15 ml. of the supernatant was concentrated to 1 ml.

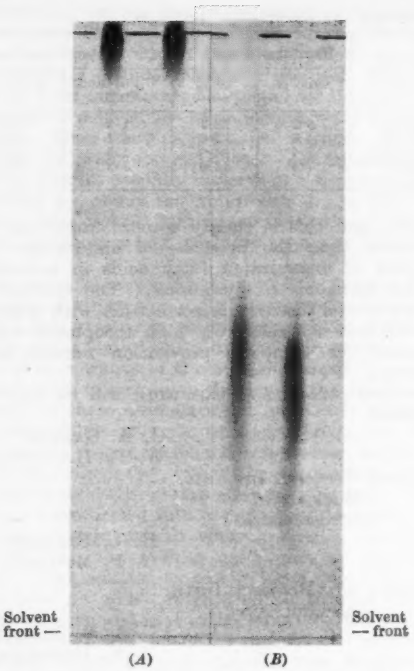

Fig. 1. Autoradiograph of copper-64 chromatograms: (*A*) copper-64 applied to chromatograms as free cupric ion; (*B*) copper-64 applied after combining with water-soluble components of herbage

by freeze-drying and 2·5 μgm. copper-64 + carrier (as copper nitrate) was added. This preparation was applied to Whatman No. 1 filter paper as spots containing 0·012 ml. liquid and the chromatogram then developed with phenol/water as (descending) solvent. Chromatograms containing an equivalent quantity of the untreated cupric ion were developed by the same procedure. Autoradiograph prints of the dried chromatograms on Ilford 'Industrial G' X-ray film were obtained by 24 hr. exposure (Fig. 1).

The absence of a radiation response in the R_F range 0·0–0·06 of the herbage-extract chromatogram indicates that all the added cupric ions have combined to form complexes stable at the solvent *p*H (4·4) despite the fact that, by this procedure, the copper content of the original extract was increased by two and a half times. The copper complex thus formed has a faint blue-green fluorescence under ultra-violet light, and gives a weak positive response with ninhydrin in butanol.

It is emphasized that, in order to produce a satisfactory autoradiograph, the above chromatograms are overloaded. By the use of more sensitive radiometric scanning methods[1,2], it should be possible to overcome this difficulty.

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Field Resistance to Potato Blight (*Phytophthora infestans*)

Two types of resistance of potatoes to blight (*Phytophthora infestans*) have been distinguished—'true resistance' by virtue of hypersensitivity (supra-sensitivity) and 'field resistance'[1]. True resistance is not found in the old varieties of European cultivated potato; but it has been bred for on an extensive scale for more than thirty years using the wild Mexican potato, *Solanum demissum*, as the source of genes for the hypersensitive reaction. It appears now that this hypersensitive type of resistance by itself is of limited value, because new physiological races of blight can arise very rapidly to attack clones carrying as many as four different major genes for hypersensitive reactions[2], and because *S. demissum* itself is attacked by blight in Mexico[3]. In contrast, field resistance, which is found in certain varieties of European cultivated potatoes and in other potato species, may be equally effective against all physiological races of blight.

The nature of field resistance was investigated by Müller and Haigh[1] and by Müller[4]. They claimed that susceptible and field-resistant varieties differed in their "probability of becoming infected per unit area of leaf", and they obtained a measure of this probability of becoming infected by spraying the upper surface of small disks of potato leaflets with a weak zoospore suspension and counting the number of disks on which sporangiophores were produced some days after spraying (susceptible and field-resistant varieties showed no differences if the under-surface of the disks were sprayed). Using two varieties, Arran Pilot (very susceptible) and Ackersegen (field resistant), we also were able to demonstrate a small but significant difference between the two varieties in the percentage of disks on which sporangiophores were produced. On the other hand, we were able to show that the disks of Ackersegen on which no sporangiophores were found did contain hyphæ of blight which could be made to produce sporangiophores by placing them on the cut surfaces of potato tubers. It thus appears that the leaflet-disk method measures "probability of producing sporangiophores per unit area of leaf" rather than "probability of becoming infected per unit area of leaf". The disk method also does not appear to be very sensitive, since it was found[1,4] that King Edward and Majestic had similar values for percentage becoming infected, whereas in field observations[5] it has been found that blight on Majestic frequently reaches the 75 per cent stage a week or a fortnight later than it does on King Edward.

Schaper[6] has suggested that field resistance is due to a longer incubation period for the fungus and a lower production of spores by the fungus when it grows on a resistant potato. This we have confirmed for Ackersegen, on which, using either detached leaflets or leaflet disks sprayed with a weak zoospore suspension, sporangiophores are produced one day later than on Arran Pilot, and the number of sporangia

Table 1

Date of inoculation	Date on which sporangia counted	Relative number of sporangia	
		Arran Pilot	Ackersegen
1/10	5/10	46·35	0·00
	6/10	89·60	6·25
	7/10	92·00	25·00
	8/10	102·95	28·15

produced is very much smaller. Details of one experiment are given in Table 1.

It would thus appear that, while susceptible and field-resistant potato varieties may differ in several characters, two of the most important differences, both of which may be due to a relatively slow growth of the fungus in the leaflets of field-resistant varieties, are the length of the incubation period of the fungus and the number of spores produced.

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Aphelenchoides sp. destroying Mushroom Mycelium

Damage to mushroom mycelium, by eelworms, leading to diminished crops or crop failures has been known for about fifty years[1]. The eelworms responsible for the damage have been reported as *Ditylenchus* sp. by Lambert, Steiner and Drechsler[2] and by Bovien[3], as *Ditylenchus destructor* by Seinhorst and Bels[4] and as a new species of *Ditylenchus* by Cairns[5]. Cairns[6] has also stated that species of *Aphelenchoides* feed upon, injure and destroy mushroom hyphæ.

Populations of *Aphelenchoides* sp. have frequently been encountered in samples of compost from poorly cropping mushroom beds.

Early this year at Wye, bottles of sterile compost already spawned with mushroom mycelium were inoculated with a mixed population of *Aphelenchoides* sp. and *Panagrolaimus* sp. At the end of four or five weeks the mycelium in the inoculated bottles had largely disappeared, and the population of eelworms had greatly increased. Some of the material was sent to Rothamsted. There one set of pots each containing 300 gm. of compost was inoculated, at the same time as spawning, with fifteen hand-picked specimens of *Aphelenchoides* and another set with fifteen similar specimens of *Panagrolaimus*. A further set of pots constituted a control. Cropping began four weeks later, and continued up to the eleventh week in the control pots and those inoculated with *Panagrolaimus*. In the pots inoculated with *Aphelenchoides* cropping ceased at the end of the sixth week. Examination of the compost showed the reason for these differences. Mycelium was present and undamaged in the control and *Panagrolaimus* series; but in the *Aphelenchoides* series it had largely disappeared. From an original inoculum of fifteen specimens of *Aphelenchoides* there were approximately 3,000,000 present at the end of six weeks. On the other hand, there were only 72,000 *Panagrolaimus*.

The identity of the *Aphelenchoides* is still under investigation. It is not true *Aph. parietinus*, as recently redescribed by Franklin[7]; both sexes are present and there are distinct morphological differences which clearly separate it from this species, although it is similar in many respects.

Fig. 1. Mushroom mycelium on compost after eight weeks: left, control; right, inoculated with *Aphelenchoides* sp.

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Control of Seasonal Variation in the Egg Production of Hens

The discovery that artificial light will improve winter egg production by hens is said to have been made about a hundred years ago by Spanish farmers[1]. It was later established in a number of laboratories that it will prevent moulting in pullets brought into lay in the autumn. Little progress has been made in defining the light stimulus except for some experiments on the effect of breaking the night[2]. More than twenty years ago it was suggested on the basis of field records that the seasonal change in day-length as opposed to the absolute day-length was mainly responsible for the seasonal fluctuations of egg yield[3]. This suggestion has never been followed up.

I have tried to examine the effect of the change in day-length in late summer and early autumn on the production of pullets already in lay. Two groups, each of twenty-one Brown Leghorns from an inbred line, were reared from the age of eight weeks, the first in a 23½-hr. and the second in a 12-hr. day-length in artificial light. The birds were kept in

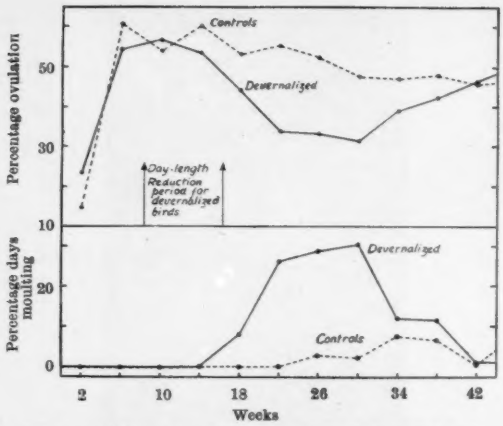

Fig. 1. Ovulation and moulting of survivors of the control group (twenty birds) and the 'devernalized' group (seventeen birds) plotted in periods of 28 days. Moulting days were those on which an appreciable number of feathers were cast, not days on which feathers were growing

batteries from this age, but previously had been in a pen. About two months after the birds had come into lay the day-length of the first group was gradually reduced to 12 hr. over a period of eight weeks and then maintained at this level. This procedure is hereafter called 'devernalization'. In this way the seasonal reduction in day-length in late summer and early autumn was simulated in an exaggerated way. Because the pullets had been in lay for some time before 'devernalization', they represented early hatched birds, which a farmer might expect to moult in the autumn. The day-length for the second group was maintained throughout at 12 hr., an absolute day-length at which good production is normally maintained.

Fig. 1 shows that the production of the 'devernalized' group fell very considerably after the day-length was reduced; it did not recover for some months, and was accompanied by moulting as in farming practice. Its cause cannot be a low absolute day-length, because the 'devernalized' group at no time had a shorter day than the controls. It is unlikely that there was a subclinical infection in the 'devernalized' group, because a fortnight after the end of the treatment the birds of the two groups were mixed. It seems, therefore, that a downward change in day-length can reduce egg production and cause moulting.

From the age of eight weeks up to the end of 'devernalization', the birds had been kept in an environmental temperature of 64° F. A fortnight later, half of each group were exposed to an artificial thermal autumn and winter lasting five months. The temperature during the coldest three weeks averaged 36° F. In agreement with most earlier work on housed birds, discussed by me[4], this had no appreciable effect on production.

A second 'devernalization', after the birds had been in lay for about a year, was successful. Production nearly ceased and moulting was heavy. Controls maintained a reasonable rate of lay.

It is thought that if late summer and autumn 'devernalization' is prevented, and the birds are kept on the intensive system, hatching in Britain could be profitably carried out at any time of the year, so that the supply and price of eggs could be fairly steady, as indeed they are already in the lower latitude of the United States. My experiments are purely fundamental and do not, therefore, indicate the most economic method of controlling 'devernalization'. However, field trials carried out by Temperton[5] suggest that the practical methods of control may be simpler than those used here.

Recent experiments at this Centre[6] show that a short absolute day-length can inhibit production as well as a reduction in day-length; however, when autumn and winter lighting are used, the absolute day-length is never short enough to reduce production in practice.

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Eophila oculata at Verulamium: a Roman Earthworm Population?

During the excavation of Roman remains lying beneath a car park near the Verulamium Museum, St. Albans, in the summer of 1955 some eighteen living earthworms were found among layers of blackened organic material between eight and fifteen feet below ground-level.

The worms were identified as *Eophila oculata* (Hoff.), a species fairly widely distributed in Britain and Europe. (The specimens were kindly examined by Dr. A. J. Cain, who wrote: "I think there is no real doubt that the worms are *Eophila oculata* (Hoffmeister 1845). Only one or two have traces of the clitellum and tubercula pubertatis, and the latter are slightly atypical in extending over segments 28–30 instead of 29–30 as usually described. Unfortunately none of the apparently most mature show even traces of the spermathecae and seminal vesicles on dissection, so the diagnosis cannot be confirmed. In the extent of the clitellum and the presence of a genital cushion on 11, and one or two other features they agree well with *oculata*.") This worm does not occur in agricultural soils but inhabits aquatic or semi-aquatic places such as the mud at the bottom of ponds, rivers and ditches and the wet soil of their banks. It has been found in wells[1], in clayey soil under rotting sedge at Wicken Fen[2], and among material dredged from the bottom of Lough Mask, Eire, at a depth of between 100 and 150 ft.[3].

The present record is unusually interesting as the worms were found in the remains of a ditch which was filled in during the first century A.D., and then sealed over by the floors of successive buildings erected between the first and fourth centuries A.D. The varying floor surfaces included tile, gravel, mortar and beaten earth, and were in a fair state of preservation. They formed a compact layer from eight to fifteen feet thick which clearly had not been disturbed since Roman times.

The ditch represented the first disturbance of the site by man and may have been a stage in the construction of a defensive ditch which was not completed. It contained, in its lower part, a water-logged black material, and in its upper part, where the worms were found, soil mixed with separate layers of partially decomposed, blackened vegetation among which brushwood, holly leaves, bracken, grass and various types of seeds were recognizable. Domestic refuse including oyster shells, pottery and scraps of leather; many identifiable fly puparia and other insect parts were also found.

Excavation began in April, but had only reached a depth of 2 ft. by July. The rate of working then increased and the ditch was entered by the end of the month. The first worms were found shortly afterwards. They were in well-developed burrows and evidently had not been introduced during the digging. The nearest likely source of this species of worm is the River Ver, 250 yards away; but as the excavation was carried out during a period of drought (total rainfall July and August, 1·06 in.) it is unlikely that they invaded the exposed ditch across the dry partly built-up area in between. No worms or burrows were found between the ditch and the lowest Roman floor and it is also unlikely that the worms would have penetrated the compacted layers, 8–15 ft. thick, above it. They might, however, have migrated along the ditch horizontally if it connected with the river. The full extent of the ditch is not known, but it almost certainly does not connect with the river as the exposed portion curves away from it and lies ten feet above it.

There remains the possibility that the worms entered the ditch in Roman times before it was filled in, and have continued to breed there ever since. This explanation is supported by the presence in the ditch of seeds of *Carex* spp., typically plants of marshy situations, which suggests that the site provided a suitable habitat for *E. oculata* during the Roman period.

Worms and burrows occurred both among the partly decomposed vegetation and in the surrounding clay. Deposits of 'vivianite' (hydrated ferrous phosphate), a substance laid down under reducing conditions, were found among the organic materials, and this, together with the well-preserved state of the vegetation itself, suggests locally anaerobic conditions. The surrounding soil may, however, have been slightly better aerated and, if so, worms in the vegetation could perhaps have obtained some air from this source through their burrows.

A number of other sites from which *E. oculata* has been recorded, for example, the black mud beneath the River Thames and the bottom of Lough Mask, similarly suggest conditions of poor aeration, and the ability of the species to exploit these habitats implies a capacity for absorbing oxygen at very low tensions.

This may be facilitated partly by its relatively large surface/volume ratio—although up to 75 mm. long, it is only 1–2 mm. in diameter. Only two other species in the British Lumbricidae, *Bimastus icenorum* (Pickford)[2] and *Allolobophora minima* Muldal[4], are similarly proportioned (diameters about 1 mm. and 1–1·5 mm. respectively) and both appear to have been found in the same type of habitat as *E. oculata*. *B. icenorum* and *E. oculata* were both collected by Pickford from "clayey soil under rotting sedge" at Wicken, and a specimen of *A. minima* was found by Muldal among preserved *E. oculata* collected by Friend from the Thames and Nottinghamshire. *B. icenorum* has been recorded only once but both *A. minima* and *E. oculata* have been taken from normally aerated sites. All three species seem to have in common at least some habitats and a body form providing an exceptionally high proportion of respiratory surface. It is tempting to speculate whether they may not also share an ability to live in habitats closed to other Lumbricidae under conditions of very restricted oxygen supply.

We are indebted to Mr. John Lunn, director of the excavation and of the Verulamium Museum, for directing our attention to this problem and for supplying us with archæological details of the site, and to Dr. A. J. Cain for identifying the worms and and for his comments on the manuscript.

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An Arctic Lichen, *Siphula ceratites*, in Scotland

I DISCOVERED a large colony of the arctic lichen *Siphula ceratites* (Wg.) Fr. in April 1955 on the Coulin Forest of Wester Ross (lat. 57° 32′ N., long. 5° 22′ W.). The species is circumpolar, markedly disjunct and predominantly coastal in its distribution[1]. It has been recorded from western and northern Norway, Swedish and Finnish Lappmark, the Petsamo area, Novaya Zemlaya, Siberia, Japan, the Aleutian Islands, the Bering Strait region and the Himalaya but not hitherto from the British Isles.

The altitudinal range of these stations is from near sea-level in south-west Norway to 15,000 ft. (4,570 m.) in the Himalaya, the usual habitat being open plant communities of wet, stony or peaty ground. In Ross-shire the lichen is abundant over some 200 acres (80 hectares) of this type of terrain at an altitude of 1,500–1,800 ft. (458–549 m.) O.D. and is apparently extending its range (Fig. 1).

Fig. 1. *Siphula ceratites* on bare peat at 1,800 ft. O.D., Ross-shire, Scotland

Voucher specimens have been deposited in the herbaria of the Royal Botanic Garden, Edinburgh, and the Nature Conservancy, Edinburgh.

I am indebted to Dr. E. Dahl, of Vollebekk, Norway, for identifying the Scottish material.

A detailed account of the Ross-shire locality of *S. ceratites* will be published elsewhere.

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Effect of Environment upon the Growth and Development of Raspberry Canes

The red raspberry (*Rubus idaeus* L.) has a perennial root system; but the shoots ('canes') are normally biennial, elongating in the first season and fruiting and dying in the second. Replacement canes may arise directly from roots, as root suckers, or from dormant buds at about ground-level on fruiting canes. This sequence of growth and development appears to be largely governed by, and in response to, various environmental factors, primarily those of light and temperature. The effects of these factors are being studied by growing plants under controlled conditions in which length of day, light-intensity and temperature can be varied independently.

Fluorescent lighting has been used, giving about 450 ft.-candles at the plant apices. Plants have been grown in three different constant temperatures, at each of which batches of plants were exposed to 9-hr. and 14-hr. day-lengths respectively. As a result of this work, some of the main effects of environment can now be discerned.

It is convenient to define three major phases of growth and development, namely: (1) the initiation of buds upon raspberry roots and their subsequent elongation to the soil surface; (2) the growth of the vegetative shoot in its first year; and (3) the production of flowers, mainly on lateral shoots, followed by fruit development and death of the cane, in the second year. Phase 1 has been discussed elsewhere[1], and is still under investigation. Phases 2 and 3 are discussed below.

Fig. 2. Plants *A* and *B* were the same age when photographed on December 10, 1955. Plant *A* was grown at 50° F. in a length of day of 9 hr. Plant *B* was grown for 12 weeks at 60° F., 14 hr. length of day, then 'cool-treated' for six weeks at 50° F., 9 hr. length of day, then cold-treated for six weeks at 36° F., 0 light, and thereafter returned to a warm glasshouse where it formed tip and lateral fruit

In phase 2, two distinct forms of growth have been produced, some shoots elongating rapidly whereas others elongated very little, producing compact rosettes of leaves. At 70° F., with a length of day of either 14 or 9 hr., all shoots grew quickly, showing no tendency to form rosettes. In marked contrast, at 50° F. rosettes were formed in both day-lengths. At an intermediate temperature of 60° F., shoots with a 14-hr. length of day elongated slowly at first but ultimately at a greater rate than those in a comparable length of day at 70° F., whereas plants grown at 60° F. with a 9-hr. length of day formed large rosettes near soil-level and did not elongate. These habits of growth are illustrated in Fig. 1.

Fig. 1. Raspberry plants propagated from root cuttings on November 3, 1954, and photographed on March 1, 1955, after growing in six different environments. *L*, length of day of 14 hr.; *S*, 9 hr.; 70, 60 and 50 are constant temperatures in degrees Fahrenheit

It is of particular interest to note the interaction of temperature and photoperiod. At temperatures of about 60° F., elongation appears to depend upon length of day, whereas at lower temperatures rosettes form, and at higher temperatures shoots elongate, irrespective of the length of day.

Response to the environment is not confined to the young shoot or to growth near ground-level. Strongly elongating shoots, up to five feet or more in length, can be induced to form terminal rosettes of leaves either by giving lower temperatures or shorter days. Conversely, a shoot which has formed a terminal rosette can be induced to elongate again if the length of day is increased or the temperature raised.

When grown at sufficiently high temperatures, in heated glasshouses, raspberry canes have continued to elongate for considerable periods and have attained lengths of more than twelve feet without showing any tendency to go dormant, even in low light-intensities and short days of winter.

Phase 3, flowering and fruiting, can be initiated by exposing plants with elongated canes to a period of low temperatures, between 35° F. and 40° F. for periods up to six weeks. With the varieties Lloyd George and Malling Promise, a short period of a few days at low temperatures resulted in the production of a terminal flowering shoot when the plants were returned to higher temperatures. On the other hand, exposure of equally mature canes to longer periods of low temperature resulted in an increasing proportion of the lateral buds growing out to form mixed fruiting laterals (Fig. 2).

During exposure to low temperatures, canes become dormant and the leaves fall. It is not necessary for plants to be exposed to light during this period. When plants have been returned to the conditions of higher temperatures and light of a glasshouse and laterals have begun to develop, length of day seems to have little influence upon further growth of the laterals and flower and fruit formation.

Exposure of the canes to a period of short days and a temperature of 50° F. before giving them the low temperature of 35–40° F. materially influences the effectiveness of the latter treatment.

The age of the cane, as measured by the number of nodes produced, is also an important factor in flower initiation and development. Young canes with fewer than twelve nodes have so far failed to flower in response to any treatment applied.

The work is continuing and will be described in greater detail elsewhere. Permission to use the photograph in Fig. 1 is gratefully acknowledged to Mr. B. Cox of *The Grower*.

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[1] Hudson, J. P., *Nature*, **172**, 411 (1953); *J. Hort. Sci.*, **29**, 27 (1954); **30**, 242 (1955).

Seasonal Sweating

Palmar sweating increases in young women when their environmental temperature is artificially raised[1], and it is therefore reasonable to suppose that palmar sweating is related directly to environmental temperature and will vary with it in the different seasons of the year. As a preliminary test of the supposition, five women aged 18–20 years were observed for a month in summer and a month in winter, menstrual months being chosen in preference to calendar months to eliminate luteal effects[2]. The menstrual cycles chosen to represent summer and winter were those which began in August and in February.

Sweating was assessed by the number of active glands in an area of skin 4 mm. square immediately distal to the central whorl of the right middle finger[3]. Three hundred counts were made under basal conditions, 156 in summer and 144 in winter, and the mean counts were found to be 60·0 and 100·1 respectively, the standard error being 7·4. Therefore basal palmar sweating in the five women investigated was suppressed in summer to a degree which, from the statistical point of view, is abundantly significant[4]. Body temperatures of the women were taken at the same time and the average found to be 0·3 deg. F. higher in the summer month than in the winter month.

The suppression of basal palmar sweating in summer cannot be a thermoregulatory phenomenon, particularly in view of the raised body temperature in the women under observation, nor, unless winter is regarded as a time of shock, can it be explained as a recovery phase from shock. But subcutaneous injection of 25 mgm. of adrenocorticotrophic hormone suppresses palmar sweating (unpublished results), and there is considerable indirect evidence that an increase in suprarenal cortical activity acts in the same way[5]. Therefore, if suprarenal cortical activity is increased in summer, the paradoxical suppression of basal palmar sweating would be explained. Increased suprarenal cortical activity would also explain various other summer phenomena of unknown etiology—for example, neutrophilia[6], increased resistance to bacterial infection[7] and low death-rate from respiratory infection[8].

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[8] *Statist. Bull., Metrop. Life Insur. Co.*, **26**, 7 (1945).

Reaction between Formic Acid and Nitrogen Dioxide

During a study of a series of compounds of general formula $R'R''CO$ with nitrogen dioxide, we have investigated the reaction of formic acid with nitrogen dioxide. The reaction was carried out using a cylindrical 'Pyrex' glass reaction vessel (volume ~ 158 c.c., surface area ~ 167 cm.^{2}) and was followed by measurement of the increase of total pressure, and photometric estimation of nitrogen dioxide. Analyses of the final products were carried out as required using standard techniques described previously[1]. Initial pressures of 0–100 mm. each reactant were used, most of the experiments being carried out at 220° C. Under these conditions, nitrogen dioxide is very little associated[2] or dissociated[3], and formic acid is almost completely present as the monomer[4].

The reaction proceeds quite readily at 220° C. according to the overall equation:

$$HCO_2H + NO_2 = H_2O + CO_2 + NO$$

In agreement with this equation, the increase of pressure at any given time was found to be equal to the pressure of nitrogen dioxide which had been used. The pressure increase – time curves are, how-

ever, unexpectedly linear for a considerable portion of reaction at 220° C., although the slope of the linear portion is proportional to the first power of the initial pressure of each reactant. It appears, therefore, that the initial overall second-order rate is in some way maintained, indicating the possibility of autocatalysis.

This is supported by the fact that added nitric oxide was found to increase the rate of reaction, whereas additions of water and of nitrogen had very little effect.

For a given mixture of formic acid and nitrogen dioxide, it was observed that the rate was increased in proportion to the amount of nitric oxide added (see Table 1).

Table 1

$p_{NO_2} = 24{\cdot}0$ mm. $p_{HCO_2H} = 30{\cdot}0$ mm.	$T = 220{\cdot}0°$ C.
p_{NO} added (mm.)	Initial rate $\times 10^3$ (mm./sec.)
0·0	0·92
9·2	1·30
21·1	1·98
39·9	2·34
56·5	2·63
72·3	2·99
151·6	5·10

Experiments were then carried out using different mixtures of formic acid, nitrogen dioxide and nitric oxide. These show that the rate of reaction can be expressed by an equation of the form

$$\frac{d(\Delta P)}{dt} = \frac{-d(NO_2)}{dt} = k_1(HCO_2H)(NO_2)\left\{1 + \frac{k_2(NO)}{k_1}\right\}$$

At 220° C., $k_1 = 3{\cdot}78 \times 10^{-1}$ l. mole^{-1} sec.$^{-1}$ } average
$k_2 = 3{\cdot}56 \times 10^{+2}$ l.^{2} mole^{-2} sec.$^{-1}$ } values

The reaction was found to be largely influenced by surface. Experiments using a reaction vessel packed with 'Pyrex' glass tubing which increased the surface/volume ratio by a factor of nine produced approximately a nine-fold increase in rate. The velocity constants quoted above should therefore be related to the dimensions of the reaction vessel used.

Further experiments on this reaction are being carried out and it is hoped to publish full details at a later date. The present observations, however, are in agreement with those concerning the reactions of a number of compounds of general formula $R'R''CO$ with nitrogen dioxide (Table 2). It appears that the presence of an easily removable hydrogen atom (that is, an aldehyde group) facilitates reaction. This does not necessarily imply that hydrogen abstraction occurs and is equally consistent with an initial addition reaction as proposed for the formaldehyde/nitrogen dioxide reaction by Pollard and Wyatt[1] and more recently extended by Walsh[5].

Table 2

R'	R''	Reaction of $R'R''CO$ with NO_2		Ref.
		Temperature range (° C.)	Comments	
H	H	118–184	Homogeneous reaction $< 160°$ C. $E = 15$ kc./m. $> 160°$ C. $E = 19$ kc./m.	1
CH_3	H	110–180	Homogeneous reaction $E = 15{\cdot}2$ kc./m.	6
OH	H	210–260	Heterogeneous reaction	This work
CH_3O	H	250	Slow reaction probably heterogeneous	This work
CCl_3	H	146	Slow reaction	6
CH_3	OH	150	No detectable reaction	6
CH_3	CH_3	146	Very slow reaction	6

Formic acid and methyl formate (which has been briefly studied at 250° C.) differ from the other compounds of this series in the heterogeneity of their reactions with nitrogen dioxide.

The effect of nitric oxide upon the former may well be due to the occurrence of a surface reaction (a possibility is the formation of dinitrogen trioxide), and this would explain why nitric oxide does not increase the rate of, for example, the acetaldehyde/nitrogen dioxide reaction.

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[1] Pollard, F. H., and Wyatt, R. M. H., *Trans. Farad. Soc.*, **45**, 760 (1949).
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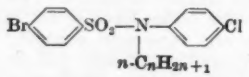
Substituted Benzenesulphonanilides as Synergists for DDT

A series of 4-bromobenzenesulphon-4′-chloroanilides of type (I) have been synthesized and tested for synergistic activity with DDT against DDT-resistant house-flies.



n = 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 12

(I)

The test subjects were of a strain '*M*' of *Musca domestica vicina* Macq. moderately resistant to DDT, which had originated in 1949 from flies caught in Rosh-Pina, Israel. The potential synergists were tested together with DDT by topical application of benzene solutions (0·175 µl. solution per fly, containing 0·175 µgm. of DDT and 0·0175 µgm. of a potential synergist). Mortality was observed 6 hr. after application. When DDT by itself was applied topically in benzene solution, *LD*25 was 1·3 µgm., *LD*50 was 5·7 µgm. and *LD*75 was 20·1 µgm. per fly. The activity of the potential synergists in the form of residual deposits was tested by a modification of the method of Mer and Davidovici[1]. House-flies were individually induced to walk for 90 sec. first over a glass surface carrying a residual deposit of 10 µgm./cm.^{2} of a potential synergist, and afterwards for the same time over a similar surface carrying 100 µgm./cm.^{2} of *p,p′*-DDT, at 24–25° C. Knock-down was recorded 3 hr. after contact.

Figs. 1 and 2 represent the biological proportional response (plotted on a probit scale) as a function of increasing alkyl chain-length n of the synergists. The observed proportional response values were analysed statistically by the method for comparing individual means proposed by Tukey[2] and elaborated by Hald[3]. This method permits the classification of means into groups which can be considered as belonging to a statistically homogeneous population of such means. The proportional mortality values observed after topical application formed two

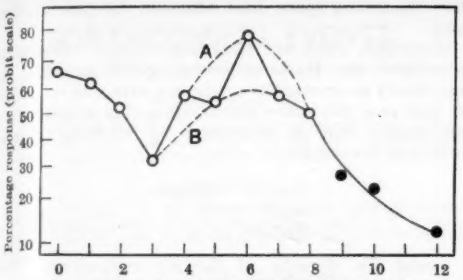


Fig. 1. Percentage knock-down of DDT-resistant house-flies 3 hr. after consecutive contacts for 90 sec. with residual deposits of 10 μgm./cm.² of N-*n*-alkyl-4-bromobenzenesulphon-4′-chloroanilide synergists and of 100 μgm./cm.² of DDT, respectively. Filled circles denote a response not significantly higher than that to DDT alone. *A*, even homologues; *B*, odd homologues

statistically homogeneous groups of responses which were significantly higher than the response to DDT by itself. These groups were {1, 2} and {0, 3, 4, 5, 6, 7, 8}, the figures in brackets denoting n of the compounds (I) in each group. The group of compounds {9, 10, 12} showed no significant synergistic activity. The proportional knock-down values observed after short-duration contact of flies with residual deposits formed three statistically homogeneous groups: {6}; {0, 1, 2, 4, 5, 7, 8}; and {3}. The remaining group {9, 10, 12} showed no significant increase of response in comparison to that caused by DDT alone (13 per cent knock-down). The level of significance for all statistical tests was $P = 0{\cdot}05$. The compounds of type (I) showed no insecticidal activity when tested by themselves by the short-contact method.

The curves of biological response versus alkyl length (Figs. 1 and 2) may be divided into three parts: low range ($n = 0$ to $n = 3$), medium range ($n = 4$ to $n = 8$), and high range ($n = 9$ to $n = 12$). In the low range, the response to contact and to topical application showed similarity. In the medium range the response to topical application showed little change, while two additional factors appeared in the contact response curve, namely, maximum response near C_6, and differentiation of the series into separate sub-series of homologues with even-numbered and of those with odd-numbered alkyl radicals. For each sub-series a separate smooth curve for response vs. alkyl chain-length resulted, and therefore the homologous series as a whole formed a zig-zag line. The curves for both sub-series were of similar ω-shape; the even homologues caused a higher response than the odd ones. In the high range ($n = 9$ to $n = 12$) the synergistic activity disappeared.

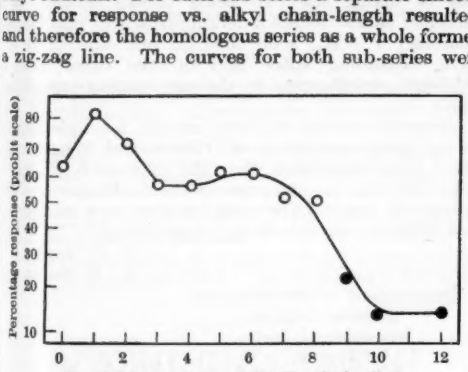


Fig. 2. Percentage mortality of DDT-resistant house-flies 6 hr. after topical application of 0·175 μgm. of DDT + 0·0175 μgm. of N-*n*-alkyl-4-bromobenzenesulphon-4′-chloroanilide synergists in benzene. Filled circles denote a response not significantly higher than that to DDT alone

For comparison several synergists which have been previously reported active when tested by other methods have been subjected to the short-duration contact test described above. 1,1-*Bis*-(*p*-chlorophenyl) ethane, which was reported by March and co-workers[4] to be highly active by topical application, showed no synergistic activity by short contact (10 per cent knock-down), while 4-chlorobenzenesulphon-4′-chloroanilide, reported by Speroni[5] to be active by 24-hr. contact, was also active by short contact (56 per cent knock-down). The N-*iso*-amyl isomer of the compound (I, $n = 5$) was inactive by topical application as well as by the short-contact test.

A detailed discussion of the observed correlation will be published elsewhere. Other synergists are being investigated.

Thanks are due to Prof. E. D. Bergmann for valuable discussions. Statistical analysis was carried out by S. Zacks.

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Kelvin on the Origin of the Earth

A geophysical discussion on the origin of the Earth reported in *Nature* some time ago[1] included an account of his so-called 'pore theory' by Mr. T. Gold. He suggested that an Earth which formed by the agglomeration of solid dust particles would, due to the heating effects of compression and radioactivity, contain a certain fraction of liquid mixed with the solid. A structure of pores or veins of liquid might be set up, and the percolation downwards and upwards of dense and light liquids could account for the formation of the Earth's core and of its atmosphere and oceans, respectively, while various hydraulic actions could explain earthquakes, vulcanism and structural features such as great upheavals.

While looking up a reference in Lord Kelvin's collected works recently, I was interested to observe that nearly one hundred years ago he had considered a similar mechanism in his article "On the Secular Cooling of the Earth"[2]. He suggested that in the process of cooling of a completely or partially liquid globe, portions of solid crust would continually sink until a "close ribbed solid skeleton or frame" had been built up from the bottom of the liquid layer. I quote what follows:

"In the honey-combed solid and liquid mass thus formed, there must be a continual tendency for the liquid, in consequence of its less specific gravity, to work its way up; whether by masses of solid falling from the roofs of vesicles or tunnels, and causing

earthquake shocks, or by the roof breaking quite through when very thin, so as to cause two such hollows to unite, or the liquid of any of them to flow out freely over the outer surface of the Earth; or by gradual subsidence of the solid, owing to the thermodynamic melting which portions of it, under intense stress, must experience, according to views recently published by my brother, Professor James Thomson. The results which must follow from this tendency seem sufficiently great and various to account for all that we see at present, and all that we learn from geological investigation, of earthquakes, of upheavals and subsidences of solid, and of eruptions of melted rock."

Lord Kelvin thus seems to have anticipated some of Mr. Gold's ideas, although they, of course, differ as to the origin of the supposed porous structure, and Mr. Gold has given more attention to what such a hypothesis might entail.

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[1] *Nature*, **175**, 575 (1955).
[2] *Trans. Roy. Soc. Edin.*, **23**, 169 (1864); "Mathematical and Physical Papers", **3**, 311.

It is interesting to know that Lord Kelvin held similar views though for different reasons, and especially that he considers also that a porous structure of the Earth would account for a variety of the phenomena that have occurred on the surface. The views of Chamberlain and Moulton, following their planetesimal hypothesis of the formation of the Earth, are perhaps even more similar to those which I have expressed. This set of ideas seems to me to have been much neglected despite the fact that it is in good accord with modern physical and geophysical knowledge.

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Influence of Expanding Space on the Gravitational Fields surrounding Individual Stars

Einstein and Strauss[1] have found solutions of the gravitational field equations of general relativity

$$G_{\mu\nu} = -k\rho v_\mu v_\nu \qquad (1)$$

$\mu, \nu = 1, 2, 3, 4$, such that (i) outside a spherical boundary $r = R_1$ (R_1 is a constant), the metric is homogeneous and isotropic, the co-ordinates are co-moving ($v_r = 0$, $r = 1, 2, 3$) and the density ρ does not vanish; (ii) inside $r = R_1$, the metric is spherically symmetric and $\rho = 0$, except for a possible singularity at or near the space-origin.

It is shown that the field inside $r = R_1$ is equivalent to the Schwarzschild field. Einstein and Strauss therefore conclude that "the expansion of space has no influence on the structure of the field surrounding an individual star".

However, Pirani[2] has shown that this negative result is obtained only because of the omission of the cosmological term $\lambda g_{\mu\nu}$ from the left-hand side of equation (1). By introducing this term, he has found that expanding space does influence the gravitational field.

Generally, stars are radiating energy. Hence we considered the Einstein–Strauss problem when the singularity at or near the origin is a source of radiation. In that case the space surrounding this singularity is not empty but is traversed by radially flowing radiation for which

$$G_{\mu\nu} = -k\sigma\omega_\mu\omega_\nu$$
$$\omega_\mu\omega^\mu = 0$$
$$(\omega^\mu)_{;\nu}\omega^\nu = 0$$

σ being the density of flowing radiation[3]. The differential equations for this field can be solved in a manner similar to that employed by Einstein and Strauss in the investigation of the field (ii) mentioned above; but a fundamental difference arises when we try to fit this radiation-field with the pressure-free cosmic field given in (i) above, over a boundary $r = R_1$. The boundary $r = R_1$ now becomes non-static and moves with the velocity of light. The necessary jump conditions to be satisfied at such boundaries are derived by O'Brien and Synge[4]. According to them, if co-ordinates are so chosen that the boundary $r - R_1(t) = 0$ becomes $x^4 = 0$ in the new co-ordinates, then one of the essential conditions is the continuity of T_k^4 at this boundary ($k = 1, 2, 3, 4$). We have found that if the Einstein–Strauss singularity radiates energy, the components T_k^4 (evaluated in the appropriate co-ordinate system) are all zero for $r < R_1(t)$, but two of them are definitely non-zero in the cosmic field $r > R_1(t)$. It is therefore not possible to make T_k^4 continuous across the boundary $r = R_1(t)$. Hence we conclude that if the Einstein–Strauss singularity radiates energy, the field (ii) for $r < R_1(t)$ can never be fitted at the boundary $r = R_1(t)$ to a pressure-free cosmic field (i) with spatially homogeneous non-zero density of matter, irrespective of the vanishing or otherwise of the cosmic 'constant' λ. The jump conditions of O'Brien and Synge allow the fitting of such radiation fields with flat space-time alone, at great distances.

According to Einstein and Strauss, the expanding space of cosmology can be fitted on to a static Schwarzschild field without influencing it. But we have now seen that as soon as the Schwarzschild's singularity begins to radiate energy, the Einstein–Strauss process of fitting the two fields breaks down. We therefore cannot locate a definite (static or non-static) boundary $r = R_1$, such that on one side of it we have expanding space and on the other side a field quite uninfluenced by the surrounding expanding space.

Since all stars are radiating energy, a simple appeal to the jump conditions of O'Brien and Synge leads one to the conclusion that the expansion of space does influence the structure of the fields surrounding individual stars. The exact nature and extent of this influence are now being investigated.

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[1] Einstein, A., and Strauss, E., *Rev. Mod. Phys.*, **17**, 120 (1945).
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FORTHCOMING EVENTS

*(Meetings marked with an asterisk * are open to the public)*

Monday, April 30

INSTITUTION OF ELECTRICAL ENGINEERS (at Savoy Place, London, W.C.2), at 5.30 p.m.—Discussion on "The Efficient Use of Technical Personnel", opened by Sir George H. Nelson, Bart.

Tuesday, May 1

FARADAY SOCIETY (in the Physical Chemistry Lecture Theatre, Imperial College, London, S.W.7), at 5.15 p.m.—Prof. J. J. Hermans (Leyden): "The Physical Properties of Polymer Solutions"* (Bourke Lecture).

Tuesday, May 1—Wednesday, May 2

INSTITUTE OF FUEL (at Church House, Westminster, London, S.W.1), at 10 a.m.—Opening Conference of a Special Study of "Domestic Heating in the United Kingdom—Present and Future".*

Wednesday, May 2

ROYAL STATISTICAL SOCIETY (at the London School of Hygiene and Tropical Medicine, Keppel Street, London, W.C.1), at 5.15 p.m.—Miss Violet R. Cane: "Some Statistical Problems in Experimental Psychology".

UNIVERSITY OF LONDON (at Senate House, London, W.C.1), at 5.30 p.m.—Prof. E. C. Wassink (Netherlands): "Morphogenetic Effects of Restricted Spectral Regions of Light in Plants".* (Further Lecture on May 3.)

SOCIETY FOR ANALYTICAL CHEMISTRY (at the Chemical Society, Burlington House, Piccadilly, London, W.1), at 7 p.m.—Dr. J. H. Hamence: "The Composition of Some Deposits and Muds in Estuaries, Rivers and Lakes".

Wednesday, May 2—Friday, May 4

INSTITUTION OF ELECTRICAL ENGINEERS (at Savoy Place, London, W.C.2)—Convention on "Electrical Equipment of Aircraft".

Thursday, May 3

FARADAY SOCIETY (in the Large Lecture Theatre, Chemistry Department, The University, Birmingham), at 4.30 p.m.—Prof. J. J. Hermans (Leyden): "Polyelectrolytes"* (Bourke Lecture).

ROYAL SOCIETY (at Burlington House, Piccadilly, London, W.1), at 4.30 p.m.—Mr. R. D. Lowde: "Spin Fluctuation Scattering of Neutrons and the Ferromagnetic State in Iron"; Mr. R. J. Eden: "The Brueckner Theory of Nuclear Structure".

LINNEAN SOCIETY OF LONDON (at Burlington House, Piccadilly, London, W.1), at 5 p.m.—Dr. J. Rzoska: "Journeying Down the Nile".

UNIVERSITY COLLEGE, LONDON (in the Physiology Theatre, Gower Street, London, W.C.1), at 5 p.m.—Prof. N. L. Edson (University of Otago): "The Intermediate Metabolism of Carbohydrate in the Mycobacteria".*

INSTITUTE OF REFRIGERATION (joint meeting with the LOW TEMPERATURE GROUP of the PHYSICAL SOCIETY, at the Institution of Mechanical Engineers, 1 Birdcage Walk, Westminster, London, S.W.1), at 5.30 p.m.—Dr. D. Smith: "The Use of Radioactive Techniques in Refrigeration Engineering".

INSTITUTION OF CHEMICAL ENGINEERS (at the Royal Institution, Albemarle Street, London, W.1), at 5.30 p.m.—Mr. H. G. Davey: "Some Problems in the Maintenance of Nuclear Reactors".

CHEMICAL SOCIETY (at Burlington House, Piccadilly, London, W.1), at 7.30 p.m.—Scientific Papers.

Friday, May 4

FARADAY SOCIETY (in the Nicholson Lecture Theatre, Department of Organic Chemistry, The University, Liverpool), at 5 p.m.—Prof. J. J. Hermans (Leyden): "Light Scattering by Solutions"* (Bourke Lecture).

INSTITUTION OF MECHANICAL ENGINEERS, HYDRAULICS GROUP (at 1 Birdcage Walk, Westminster, London, S.W.1), at 5.30 p.m.—Dr. S. P. Hutton: "Three Dimensional Motion in Axial Flow Impellers"; Dr. E. A. Spencer: "The Performance of an Axial Flow Pump".

INSTITUTE OF PHYSICS, NON-DESTRUCTIVE TESTING GROUP (at 47 Belgrave Square, London, S.W.1), at 6.30 p.m.—Symposium on "Principles of Penetrant Methods".

ROYAL INSTITUTION (at 21 Albemarle Street, London, W.1), at 9 p.m.—Prof. J. Z. Young, F.R.S.: "The Discrimination of Shapes by Animals and Machines".

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

CHEMIST (with an honours degree in chemistry or A.R.I.C., or equivalent qualifications, and at least three years experience in the industrial chemistry field) at the Atomic Weapons Research Establishment, Aldermaston, Berks, for duties which will include the control of water-treatment plants, trade waste treatment and radioactive effluent treatment and disposal systems, special laundry for contaminated protective clothing and the decontamination of plant and equipment—The Senior Recruitment Officer, Atomic Weapons Research Establishment, Aldermaston, Berks, quoting Ref. 1104/34 (May 2).

ANIMAL PHYSIOLOGIST (with an appropriate honours degree or equivalent qualification) to undertake experimental work with hill sheep—The Secretary, Hill Farming Research Organization, 48 Palmerston Place, Edinburgh 12 (May 5).

ASSISTANT, Grade B (with an honours degree in botany or zoology and able to teach both subjects to the advanced level of the general certificate of education), TO TEACH BIOLOGY in the Natural Science Department—The Principal, Derby and District College of Technology, Normanton Road, Derby (May 5).

DEPUTY LIBRARIAN (Chartered Librarian)—The Registrar, College of Technology, Suffolk Street, Birmingham 1 (May 7).

LECTURER, Grade B (with a good honours degree of a British university, and preferably teaching experience) IN MATHEMATICS—Clerk to the Governing Body, Battersea Polytechnic, London, S.W.11 (May 11).

ASSISTANT EXPERIMENTAL OFFICER (with a degree in botany or an allied biological science) IN THE DEPARTMENT OF PLANT BREEDING to assist with cytological studies of horticultural crops—The Secretary, John Innes Horticultural Institution, Bayfordbury, Hertford, Herts (May 12).

HEAD (with high academic qualifications in engineering with industrial, and, preferably, research experience, and capable of directing the teaching and administration of a large and expanding department) OF THE DEPARTMENT OF CIVIL, MECHANICAL AND MARINE ENGINEERING, City College of Technology, Liverpool—The Director of Education, 14 Sir Thomas Street, Liverpool (May 12).

SCIENTIFIC OFFICER or SENIOR SCIENTIFIC OFFICER (with a first- or second-class honours degree or equivalent in statistics or mathematics, and experience in design and analysis of scientific investigations, and preferably with some knowledge of forestry or other biological subject) AT THE FORESTRY COMMISSION RESEARCH STATION, near Farnham, Surrey, for statistical work—The Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting A.127/6A (May 12).

FELLOW IN THE DEPARTMENT OF PARTICLE PHYSICS to assist in the completion, operation and experimental use of a 10-BeV. proton synchrotron—The Registrar, Australian National University, Box 4, G.P.O., Canberra, A.C.T., Australia (May 14).

ASSISTANT LECTURER IN STATISTICS—The Registrar, The University, Hull (May 15).

LECTURER IN ZOOLOGY—The Secretary, The University, 38 North Bailey, Durham (May 15).

LECTURER (preferably with a qualification in physical organic chemistry, and an interest in infra-red spectroscopy) IN ORGANIC CHEMISTRY, at the University of Adelaide, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, May 15).

FIELD PEDOLOGIST (with a university honours degree in science or agricultural science, preferably with postgraduate research experience), at the headquarters of the Division of Soils, Commonwealth Scientific and Industrial Research Organization, Adelaide, to undertake surveys and field studies of Australian soils—Chief Scientific Liaison Officer, Australian Scientific Liaison Office, Africa House, Kingsway, London, W.C.2, quoting Appointment No. 270/129 (May 19).

LECTURER IN TECHNICAL MATHEMATICS—The Assistant Secretary, The University, Edinburgh (May 19).

LECTURER (preferably with a veterinary qualification) IN THE DEPARTMENT OF VETERINARY PHYSIOLOGY—The Assistant Secretary, The University, Edinburgh (May 19).

LECTURER (preferably with some knowledge of microwave techniques) IN ELECTRICAL ENGINEERING—The Registrar, The University, Sheffield (May 19).

RESEARCH BIOCHEMIST IN THE REGIONAL PASTORAL LABORATORIES, Division of Animal Health and Production, Commonwealth Scientific and Industrial Research Organization, Armidale, N.S.W., Australia, to conduct a series of investigations into biochemical aspects of the soil–plant–animal relationship, with particular reference to sulphur metabolism, as part of a general programme concerned with the utilization and management of native and sown pastures—Chief Scientific Liaison Officer, Australian Scientific Liaison Office, Africa House, Kingsway, London, W.C.2, quoting Appointment No. 208/83 (May 19).

ELECTRICAL ENGINEER OR PHYSICIST (with a first- or second-class honours degree or equivalent in electrical engineering or physics, and preferably with a good physics and electronics background) at an Air Ministry Experimental Establishment in Norfolk, for the development of airborne radio receiving and transmitting equipments and their associated aerial systems operating mainly on centimetric wave-lengths—The Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting A.134/6A (May 21).

RESEARCH FELLOW IN THE DEPARTMENT OF MATHEMATICAL PHYSICS—The Registrar, The University, Birmingham 15 (May 22).

LECTURER (Grade II) or ASSISTANT LECTURER (Grade III) IN BOTANY—The Registrar, The University, Birmingham 15 (May 26).

RESEARCH FELLOWS (3) (with a good honours degree in physics, mechanical or chemical engineering) IN THE DEPARTMENT OF TEXTILE INDUSTRIES—The Registrar, The University, Leeds 2 (May 28).

LECTURER (with special experience in virus diseases) IN MICROBIOLOGY—The Secretary, Queen's University, Belfast (May 30).

ASSISTANT LECTURER IN PHYSICS—The Registrar, University College of North Staffordshire, Keele, Staffs (May 31).

ASTRONOMER ROYAL FOR SCOTLAND AND PROFESSOR OF ASTRONOMY in the University of Edinburgh—The Private Secretary to the Secretary of State, St. Andrew's House, Edinburgh 1 (May 31).

BOTANIST (Assistant Experimental Officer grade) for developmental and anatomical studies of fruit—The Secretary, East Malling Research Station, near Maidstone, Kent (May 31).

LECTURER IN INDUSTRIAL METALLURGY—The Registrar, The University, Birmingham (June 1).

STEETLEY RESEARCH FELLOW (graduate, or student graduating this year, of any British university), for research in refractories technology—The Registrar, The University, Sheffield (June 12).

SENIOR LECTURER (specialized in some branch of pure mathematics, applied mathematics, or mathematical statistics) IN MATHEMATICS, at the University of Western Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, June 15).

ASSISTANT CHEMIST (with a degree in chemistry or agricultural chemistry or A.R.I.C.), for analytical work on crops and soils; and a HORTICULTURALIST or CHEMIST (with a degree in horticulture or chemistry), for glasshouse work on soils and crop nutrition—The Secretary, Rothamsted Experimental Station, Harpenden, Herts, quoting Ref. 103.

ASSISTANT CONSERVATORS OF FORESTS in the Local Civil Service, Gold Coast Government—The Secretary for Recruitment, Gold Coast Office, 13 Belgrave Square, London, S.W.1.

ASSISTANT, Grade A, TO TEACH PURE AND APPLIED MATHEMATICS—The Principal, Technical College, Queen Street South, Huddersfield.

ASSISTANT OR ASSOCIATE PROFESSOR IN THE DEPARTMENT OF PHYSICS—J. H. L. Johnstone, Department of Physics, Dalhousie University, Halifax, N.S., Canada.

BIOCHEMIST (with a first- or second-class honours degree in biochemistry or equivalent qualification, and postgraduate research experience), to assist in the study of certain physico-chemical properties of mucin—The Secretary, National Institute for Research in Dairying, Shinfield, Reading, quoting Ref. 56/3.

CHEMISTS, Grade III (with an honours degree in chemistry or chemical engineering, or A.R.I.C. or A.M.I.Chem.E., or equivalent qualifications) with the Ministry of Supply at Chorley, Lancs, to assist in process study, chemical engineering, design and experimental work on new process plant of unusual nature—The Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting F.238/6A.

LECTURER IN AGRICULTURE, and an ASSISTANT LECTURER IN DAIRYING—The Principal, Seale-Hayne Agricultural College, Newton Abbot, Devon.

LECTURER OR ASSISTANT PROFESSOR IN THE DEPARTMENT OF MATHEMATICS, Joint Faculty of Arts and Science at Dalhousie and King's Universities—Dean of Arts and Science, Dalhousie University, Halifax, Nova Scotia.

LECTURER (with good graduate qualifications in physics, with industrial and/or teaching experience, and preferably research experience) IN THE DEPARTMENT OF PHYSICS, City College of Technology, Liverpool—The Director of Education, 14 Sir Thomas Street, Liverpool 1.

LECTURERS (2) (with research interest in applied mathematics or statistics) IN MATHEMATICS—The Secretary, Royal Technical College, Glasgow.

MASTER TO TEACH PHYSICS (including advanced and scholarship levels)—The Headmaster, Bishops Stortford College, Herts.

PHYSICIST (graduate, with a knowledge of mass spectrometry and its associated vacuum techniques, and modern electronic circuitry) IN THE BIOPHYSICS DEPARTMENT of the Postgraduate Medical School (University of London), to continue the development and application of a mass spectrometer for rapid and continuous analyses of gas blends in respiratory research—The Dean, Postgraduate Medical School of London, Ducane Road, London, W.12.

RESEARCH SCHOLARS (with graduate or equivalent qualifications) IN THE DEPARTMENT OF CHEMISTRY, COLOUR CHEMISTRY AND DYEING and/or OTHER DEPARTMENTS—The Principal, Technical College, Queen Street South, Huddersfield.

SCIENTIFIC OFFICER (Entomologist) to work on insecticides derived from plants; and EXPERIMENTAL OFFICERS (male or female, with a knowledge of zoology, and preferably chemistry), one for histological and one for ecological work on the action of insecticides—The Secretary, Rothamsted Experimental Station, Harpenden, Herts.

REPORTS and other PUBLICATIONS

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Ministry of Agriculture, Fisheries and Food. Food Standards Committee Report on Copper—Revised Recommendation for Limits for Copper Content of Foods. Pp. 5. (London: H.M. Stationery Office, 1956.) [152

Air Ministry: Meteorological Office. Professional Note No. 116: Variations of the Measured Heights of Pressure Surfaces. By D. H. Johnson. Pp. 19. (M.O. 524p). 9*s*. net. Geophysical Memoir No. 97: Some Features of Jet Streams as Shown by Aircraft Observations. By R. Murray. Pp. 26. (M.O. 584e). 4*s*. 6*d*. net. (London: H.M. Stationery Office, 1956.) [152

Proceedings of the Royal Physical Society of Edinburgh. Vol. 24, Part 3: Primates in the Royal Scottish Museum. Part 2: Platyrrhini. By W. C. Osman Hill. Pp. 49–62+4 plates. (Edinburgh and London: Oliver and Boyd, Ltd., 1955.) 2*s*. 6*d*. [152

Planning. Vol. 22, No. 392: Publishing and Bookselling. Pp. 20. (London: Political and Economic Planning, 1956.) 2*s*. 6*d*. [152

British Museum (Natural History). Supplement to the Catalogue of the Vascular Plants of S. Tomé (with Principe and Annobon). By Arthur Wallis Exell. Pp. iv+58. 12*s*. 6*d*. Bulletin of the British Museum (Natural History). Entomology. Vol. 4, No. 2: New Species of Ephemeroptera from Uganda. By D. E. Kimmins. Pp. 69–87. 5*s*. (London: British Museum (Natural History). 1956.) [152

Philosophical Transactions of the Royal Society of London. Series A: Mathematical and Physical Sciences. No. 952, Vol. 248 (9 February 1956): Analytical Treatment of Two-Dimensional Supersonic Flow 1: Shock-Free Flow. By J. J. Mahony and R. E. Meyer. 2: Flow with Weak Shocks. By J. J. Mahony. Pp. 467–515. 15*s*. No. 953, Vol. 248 (9 February 1956): The Flow of Water Through the Straits of Dover Related to Wind and Differences in Sea Level. By K. F. Bowden. Pp. 517–551. 11*s*. The Year Book of the Royal Society of London, 1956. (No. 60.) Pp. 351. 15*s*. (London: Royal Society, 1956.) [152

The National Formulary 1955. First Amendment 1956. Pp. 6. (London: Pharmaceutical Press, 1956.) 6*d*. [152

The Water Research Association. Pp. 15 (1 plate). (Redhill: Water Research Association, 1956.) [152

Forestry Commission. Leaflet No. 15: Felted Beech Coccus. Pp. 8. (London: H.M. Stationery Office, 1956.) 6*d*. net. [152

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Aluminium Development Association. Information Bulletin No. 21: Aluminium in Contact with Other Materials. Pp. 48. (London: Aluminium Development Association, 1955.) 2*s*. [202

Parliamentary and Scientific Committee. Annual Report, 1955. Pp. 22. (London: Parliamentary and Scientific Committee, 1956.) [202

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Tanganyika: Geological Survey Department. Bulletin No. 28: The Geology and Ecology of the Nachingwea Region: a reconnaissance survey of Topography, Soils, Vegetation and Geology in the Southern Province of Tanganyika. By Dr. D. R. Grantham. With contributions by R. D. Pilson. Pp. viii+33+3 plates. (Dar-es-Salaam: Government Printer, 1955.) Shs. 7/50. [152

Merentutkimuslaitoksen Julkaisu—Havsforskningsinstitutets Skrift. No. 165: Regular Observations of Temperature and Salinity in the Seas Around Finland, July 1952–June 1954. By Gunnar Granqvist. Pp. 43. No. 166: The Summer Cruise with M/S *Aranda* in the Northern Baltic, 1954. By Gunnar Granqvist. Pp. 56. No. 167: Observations on Currents and Winds Made on Board Finnish Light-Ships during the years 1952, 1953 and 1954. By Eugene Lisitzin. Pp. 76. No. 168: Vattnets Temperatur och Salthalt i Nagu Skärgård. 1: Observationsmaterialet 1952–54. Av Gunnar Granqvist. Pp. 26. No. 169: Die Eiswinter 1880–1949 im Licht der Zeitanalyse. Von Risto Jurva und Erkki Palosuo. Pp. 12. (Helsinki: Merentutkimuslaitos—Havforskningsinstitutets, 1955.) [152

The National Research Council Review, 1955. Pp. 268+16 plates. (N.R.C. No. 3678.) (Ottawa: Queen's Printer, 1956.) 75 cents. [152

Berichte des Deutschen Wetterdienstes. Nr. 20 (Band 3): Über vertikale Temperatur-, Feuchte- und Windgradienten in den untersten 7 Dekametern der Atmosphäre, den Vertikalaustausch und den Wärmehaushalt an Wiesenboden bei Quickborn/Holstein 1953/1954. Von Ernst Frankenberger. Pp. 17 (mit 24 Abbildungen und 29 Tabellen im Text bzw. im Anhang). (Bad Kissingen: Deutschen Wetterdienstes, 1955.) [152

Fiskeridirektoratets Skrifter. Serie Havundersøkelser. (Reports on Norwegian Fishery and Marine Investigations.) Vol. 11, No. 3: Continuous Oxygen Recording in Seawater. By Ernst Føyn. Pp. 8. Vol. 11, No. 4: Zooplankton in Relation to Hydrography in the Norwegian Sea. By Kristian Fredrik Wiborg. Pp. 66. (Bergen: A/S John Griegs Boktrykkeri, 1955.) [152

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